REFINER
AND NATURAL GASOLINE MANUFACTURER

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GEORGE REID
Editor

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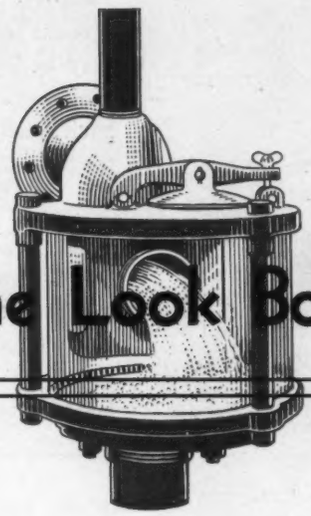


The Look Box

EVIDENCE that the petroleum industry is operating along conservative lines while facing unprecedented increases in demand for certain products was presented by the American Petroleum Institute in a review of the industry's statistical position as of the middle of August.

Statistical Position Good

Sales of gasoline were reported to be running above expectations, with indications that total domestic motor fuel demand for 1935 would establish an all time record. During the first half of 1935 domestic demand increased 3.4 percent, and total demand, with exports included, increased three percent over the first half of 1934.

Gasoline exports were revealed as close to the 1934 level and showing no large reduction for the first time since 1931. Also, for the first time during the past four years, seasonal demand for gasoline reached its full trend. These were interpreted as indications that total demand for 1935 would be more than four percent above that of 1934, but warning was sounded that despite gains in sales of motor cars and trucks, gasoline consumption in the last quarter of 1935 might fall below the abnormally high level reached in the last quarter of 1934.

Stocks of gasoline on August 1 were approximately 1,700,000 barrels less than on the corresponding date of 1934, with economic working stocks of 51,110,000 barrels in storage September 30, this year, possible of realization. California's reduction of 3,700,000 barrels in stocks was reported to have contributed substantially to the improved storage situation. The figures indicated that some refinery districts may experience difficulty in reducing stocks to economic levels by September 30. In this regard, it was explained that experience indicates that the industry should closely watch its operations in relation to the decline in seasonal demand if it desires to avoid an uneconomically high inventory position as of March 31, 1936.

Continuous improvement was reported in regard to stocks of crude oil, with the estimated 330,730,000 barrels in storage on July 20, representing the lowest recent level of above-ground stocks since 1926. Withdrawals of crude oil from stock up to July 20 were reported to average 17,000 barrels daily below those of 1934. Indications were that the supposed surplus of crude oil immediately available for refining is smaller than is generally supposed.

While a decline of 6,000,000 barrels was reported

in gas and fuel oil in storage as of June 30, when compared with a year ago, the report stated that the industry might experience a 1935 demand at only about the 1934 level, and might expect overproduction and overstocking in some areas because unexpectedly high levels of gasoline demand have caused relatively high rates of crude runs to stills, and therefore, higher fuel oil production. Distillate fuel consumption was reported as showing satisfactory gains. Substantial increases in sales of domestic and industrial oil burners during the first half of 1935 were taken to indicate that the additional inventories east of California possibly may not prove too burdensome.

Oil Pays The Freight

ONE dollar of every $10 received by American railroads from revenue carload freight in 1934 came from hauling petroleum products. Total income of Class 1 railroads from freight on carload lots of petroleum products amounted to $243,156,205, according to data obtained by the American Petroleum Institute from Interstate Commerce Commission reports.

Tonnage in 1934 showed a 6.1 percent increase over that of 1933, and there was also a gain of 2.5 percent in revenue from petroleum products transported. The total tonnage of 55,776,394 tons does not include less than carload freight, for which data were not available.

The railroads received $9,406,266 for transporting 3,381,099 tons of crude oil. A total of 36,037,792 tons of refined oils and gasolines were carried to produce revenue of $172,517,432. Carload shipments of fuel, road, and residual oils amounted to 10,688,017 tons, producing income of $33,393,764. Lubricating oils and greases were shipped in carload lots to the extent of 2,750,717 tons, with revenue amounting to $17,003,160. Asphalts shipped in carload lots totalled 2,729,265 tons, producing $9,681,216 in freight revenue. Miscellaneous products in carload lots totalled 189,504 tons, producing $1,154,367 revenue.

Oil Shortage?

WHILE some oil men are afraid that new fields may shortly cause temporary overproduction and low prices, at least two men, peering into the future, see signs of an oil scarcity and high prices in the United States within five to eight years. L. C. Snider, geologist for Henry L. Doherty & Company, New York, and Dr. Benjamin T. Brooks, consulting chemical engineer, of New York, pointed to the possibility of such a a shortage in a paper presented last month in San Francisco before the American Chemical Society.

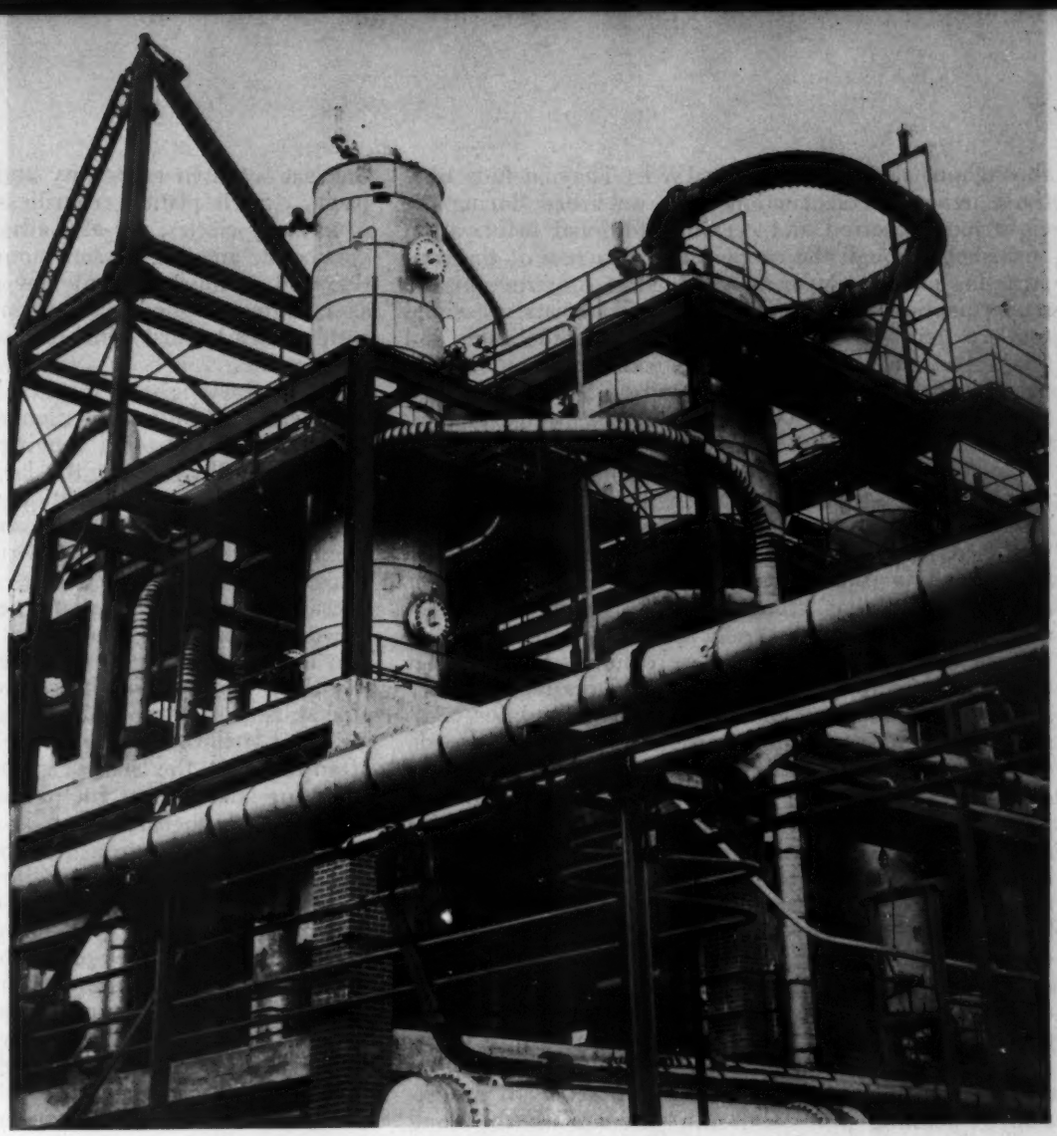
Highlights of the Brooks-Snider paper: There is abundant evidence for expecting a shortage of oil sufficient to necessitate marked increase of imports and substantial increase of the oil price structure within five to eight years. If consumption increases materially, a shortage may develop within two or three years. The shortage may force a more general use of small, low-powered motor cars. It would likely lead to production of substitutes, including oils made from shale and coal, particularly after rise of crude prices to around 2½ or three times present postings. While present known reserves may be *equivalent* to 10 or 12 years' requirements, they could not be economically recovered within such period; in fact, new supplies of considerable magnitude will be needed within about five years.

Fuller's Earth

THE work of filtering, bleaching, clarifying and decolorizing mineral oils continues to supply a market for over 91 percent of the domestic production of fuller's earth. The industries working with vegetable oils and animal fats consumed but about 7 percent of the fuller's earth production, and the "miscellaneous uses" approximately one percent. In the refining industry the chief function of fuller's earth is one of clarifying lubricating oils, medicinal oils, and the like. Straight filtering of certain types of cracked gasoline is no longer practiced on an important scale. Newer processes, such as the Osterstrom, Stratford, and the widely used Gray process, continue to provide important outlets for earth production. Certain other processes under development bid fair to boost the demand for earth. On the other hand, certain of the contact processes continue making inroads on earth consumption, through increasing use of the bentonites.

Production of fuller's earth in 1935, according to releases from The Bureau of Mines, amounted to 220,264 short tons, valued at $2,085,081 ($9.37 per ton). For the fourth consecutive year, production of fuller's earth in the United States declined in 1934. While the decline was slight, amounting to only 1.7 percent, as against the preceding year, it was notable because it continued a downward trend in the output of a mineral whose production has shown a rapid and almost uninterrupted increase over a period of 35 years. The decrease in tonnage was accompanied by an increase of nine cents per ton in the average price at which the mineral was sold, and the net result was a slight increase in total value. Sixteen plants in eight states operated by 14 companies reported production of fuller's earth in 1934. Most of the production came, as in previous years from deposits in Georgia and Florida; in fact, these two states accounted for 67 percent of the total output for the country.

(*Continued on page 45a*)



Solvent recovery system of distillation and fractionation used in conjunction with Soconoy-Vacuum Oil Company's new solvent refining plant at Paulsboro, New Jersey

$49,000,000 Construction . . . This Year

Technical Advance and Economic Conditions Contribute to Building Activity

GEORGE REID

SEVERAL important factors contribute to the present wide-spread activity in construction in the manufacturing branch of the petroleum industry. Throughout the world there is a general trend toward replacement of worn out equipment; a condition brought about by obsolesence of processing facilities in most instances, and given acceleration through the availability of highly efficient modern facilities. The efficiency of combination units that skim, crack and reform the naphtha fraction in one operation, has been sufficiently demonstrated that petroleum technologists recognize the fact that older methods of operation should be termed obsolete.

In the lubricating oil field the adoption of solvent methods of refining and dewaxing is progressing more rapidly than was thought possible by many. In the foreign refining countries the acceptance of American standards of operation is strikingly apparent, and foreign activities in regard to modernization and establishment of new refining centers have had a tendency to closely parallel the activities and expenditures for similar work in the United States.

A survey of available information relative construction activities during the first eight months of 1935 brings to light some interesting and important information. Elsewhere in connection with this discussion are presented lists of construction activities in this country and abroad. These items, although their total is impressive, can not possibly represent all construction work

throughout the world during 1935. They include only those items of construction news published during the eight month period and certain additional information furnished through the cooperation of a few of the constructing engineering firms engaged in construction and modernization of refineries. The partial lists presented total 76 items of construction in the United States and 30 projects in foreign countries. The total money expended for this work is estimated at $49,000,000. Of this amount $29,000,000 has been or is being spent in the United States and $20,000,000 in foreign countries.

One of the striking developments noted in the compilation of these data is what might be termed the "return" of the reforming unit. In virtually all instances where major projects in cracking plant construction or modernization is under way, facilities are included for reforming naphthas. Incidentally, a review of the vast amount of construction under discussion confirms previously expressed views in these columns to the effect that the refining industry must of necessity do much about the modernization of its cracking facilities. Approximately 35 of the larger projects listed have to do with new cracking units or modernization of existing cracking facilities. In this new work the reforming phase is present, as stated above, in most instances, and such a condition is attributed to the fact that refiners have found that a motor fuel of better mileage characteristics, in addition to better knock rating, is produced by reforming straight-run naphthas, than can be produced by blending cracked gasolines with straight-run distillates. The chemical composition of cracked gasoline and reformed gasoline, as well as the physical characteristics makes such products better fitted for consumption by the modern automobile engine. This acknowledgement, and the growing practice to utilization of refining processes, simply confirms the long known fact that "cracked gasoline is the best."

As to the actual construction work and its location, perhaps the most important factor is that of the rapidity and intensiveness of development of refining industries in foreign countries. The past two years has seen the course of flow of oil through world marketing channels rapidly changing, and the change will continue to manifest itself through the next few years. The well formed nationalistic programs of such countries as France, Germany, England, Roumania, Spain, Italy, Japan, to mention a few, are actively seeking conditions wherein each country will be independent of others, especially with regard to oil. Where petroleum is not produced within the borders of the country, there still can be a domestic refining industry which can provide that country with the petroleum products required within itself. No one overlooks the fact, on the other hand, that the United States greatly aided in the stimulation of development of refining in foreign countries through placing high import duties on foreign crude oil. The most important reaction to this policy was the establishment of the very large refineries in the Dutch West Indies. In the European countries, high duties on finished products made advisable the establishment of plants within the borders of those countries.

Another factor concerning which companies operating on a far flung front throughout the world are reticent to discuss, is the possibility of another world wide conflict with its inevitable embargoes and still more inevitable hazards to shipping and operation. With the possibility of such war conditions being brought about ultimately, it is well that each of the countries not only have refining interests both within their boundaries and in their island possessions, but that these refineries be the last word in modernity and of relatively large capacity. Such plants, regardless of what may develop in military circles, are also advisable from an economic viewpoint, and the present activity in both modernization and establishment of new plants is to be accepted as a matter of good business in being prepared for the better times toward which the world is struggling—and progressing.

In the cracking field the trend continues definitely toward erection of combination distillation and cracking units of large capacity, ranging from 20,000 to 30,000 barrels per day, among the larger companies with the larger refineries. Combination units of 3000 to 10,000 barrels are being used more and more extensively on the yards of the smaller refineries. These processes are being erected where refineries are expanding existing operations, especially where new refineries are established. Among the established concerns, the combination units are going in wherever management can justify their existence at the cost of doing away with old pipe stills or shell still batteries, old furnaces, and cracking units of the vintage of 1924-26. Such justification is often found on the basis of savings effected through less operating labor, lower fuel consumption and better products with higher recovery is often possible. Initial costs of such installations are however, fairly high. This factor will not long retard the widespread application of such processes if economic conditions continue improving.

Process in the development of distillation equipment has been of real importance during the past few years. With certain types of crude, specially designed distillation equipment may be necessary for some time to come, and on the other hand, such designs may be deemed necessary for a longer period than is actually the case so far as crude oils are concerned. For specific purposes of individual refineries, progress and knowledge of distillation and fractionation is definitely required, for in the manufacture of specialties, in the growing art of synthesis, in the recovery of solvents, and production of highly specialized fractions, there is much need for distillation facilities of various types and of high efficiency. The modern high capacity tube still has definitely rendered obsolete all former forms of distillation apparatus.

Solvent refining in lubricating oil manufacture is here to stay. Its features and advantages are now too well known for reviewing here. In operation solvent refining tends to replace sulfuric acid treatment and its use permits the complete recovery and use of the oil which is removed, and this along with the purposes of increasing paraffinicity of the oil, obtaining a lower coefficient of viscosity change with temperature, or a higher viscosity index, and along with securing resistance to sludging, oxidation, and lower carbon residues, accounts for its popularity. Further, solvent processes have been shown better economy of operation than the older established processing methods. The solvents now of chief importance in commercial installations are sulfur dioxide, sulfur dioxide and benzene, phenol, Chlorex, nitrobenzine, propane and cresylic acid and furfural.

The process involving treatment of oils with liquid propane is another tool available to the refiner, and being used to some extent. Propane, as a solvent, dissolves the oil and precipitates the asphaltic substances, becoming then a deasphaltizing process as well. Inasmuch as dewaxing may be accomplished in propane solution there becomes available a wide variety of applications and uses not only in lubricating oil manufacture but in concentration of asphaltic materials which

may prove of advantage in preparation of selected cracking stocks.

Solvent dewaxing has found wide application recently and its popularity continues growing. It has been found, for example, that with some solvents the needs for separating the so-called crystalline and amorphous waxes in two fractions for further refining in two separate processes, may be eliminated. With certain solvents it is claimed, and to a large extent proven in refining practice, that all types of wax can be removed with crystals sufficiently large to secure good results in conventional wax separating apparatus. The solvents now used principally for such work are liquid propane, acetone and benzol, and trichlorethylene. In regard to further possibilities with dewaxing, J. Bennett Hill, Sun Oil Company, writing in Industrial and Engineering Chemistry, May, 1935, states "Since these processes [solvent dewaxing] are applicable to any kind of stock, they permit dewaxing of cuts from the pipe still which were previously regarded as hybrid between light and heavy oils and which could not be dewaxed by either of the old types of processes. These new processes as they develop will probably be capable of producing in a reasonably oil-free condition the higher melting and higher boiling waxes which have not previously been isolated to any considerable extent. We may therefore look for an extension of the range of properties available in paraffin wax." One application of solvents to this problem of higher melting point wax production has been commercially and successfully applied by an Oklahoma refiner and with the results that some interesting as well as easily marketed waxes are being produced.

Extensive use of the polymerization plant as a tool for production of additional gasoline and better gasoline bids fair to come about within much shorter time than was estimated a few months back. Several of these plants now are in operation and with others proposed. The gases produced by cracking, its steady volume and low value, have spurred on certain research workers for the past several years and close contact with some engaged in the research and the knowledge of rapidity of the development has contributed to certain prophetic editorial treatments in these columns during recent years. Polymerization plants as now available commercially polymerize the olefins in cracking plant gas to liquids boiling in the gasoline range. The newer processes will decompose the paraffin hydrocarbons in the gas to olefins and then polymerize these olefins into liquids of high octane value for use in motor fuels. With this definitely established, and with recovery or yields running usually around five gallons per thousand, and with promise of even higher recoveries, it is not without the realm of reason to not only expect "poly" plants wherever there is a battery of cracking units, but also to expect a time when such plants will operate successfully on natural gas. Certain it is that the "poly" plant will come to the refinery at its present state of development and remove some of the functions of the present absorption gasoline recovery plants in the refinery yards.

This discussion of the technical progress within the industry which continually tends to bring about additional construction of newer, finer and more scientific processes in the world's refineries, can be at best only partial in its scope, and can not hope to enumerate all of the advances in technology and engineering which bring about a constant state of obsolescence in first one department of the refinery and then another. The discussion of the economic influences at work, and the presentation of the lists of construction activities throughout the world, are likewise, of necessity, incomplete. The discussion and enumeration, however, does forcibly bring to light the important fact that the refining industry is cognizant of its state of repair, its state of progress or lack thereof, and is intent upon doing something about it. Given fair prices for its products which will assure operation on the profit side of the ledger and such wide activities in modernization and establishment of new highly efficient operating units will continue. Fortunately, indications as to recovery from the five years of depression are favorable and a continuance of favorable indications will see still further activities among the refineries of the world.

Partial List

Refinery and Gasoline Plant Construction

in the United States During 1935

American Bitumuls Company, East Providence, Rhode Island, plant installed a 150-ton vacuum unit for production of asphalt products, with contract to E. B. Badger & Sons Company.

Associated Oil Company, Los Angeles, gave contract to Braun Corporation for construction of stabilizer and fractionator unit. Alco Products, Inc., completed a new butane recovery plant. E. B. Badger & Sons Company, earlier this year had completed reconstruction of the redistillation facilities, and later completed additions to increase production of lubricating oils and asphalt, through installation of a 2000-barrel pipe heater and vacuum tower. In March the company announced that it would spend $575,000 for improvements at the Watson and Avon refineries.

Atlantic Refining Company, Philadelphia, is installing Gray Processes Corporation, Gray liquid phase clay treating system, in connection with its new combination cracking and skimming plant recently completed.

Black Gold Refining Company, Oklahoma City, under license from Universal Oil Products Company is completing erection of a 1000-barrel Dubbs cracking unit with design to permit addition of second heating coil later.

Bradford-Penn Refining Corporation, Clarenden, Pa., has completed installation of new solvent refining plant.

Canfield Oil Company, Corapolis, Pa., has completed reconstruction of filtration plant destroyed by fire this summer. Contract to The Austin Company.

Carbide & Carbon Chemicals Corporation completed a $10,000,000 chemical plant at Whiting, Indiana, where it manufactures chemical products from waste gases from Standard Oil Company (Indiana) refinery.

Carter Oil Company, Tulsa, moved equipment from Seminole plant to the Fitts pool, Pontotoc County, where it erected a 25,000-gallon natural gasoline plant.

Cities Service Refining Company, East Braintree, Mass., modernized refinery during the year through the addition of new combination skimming and cracking facilities.

Continental Oil Company at Baltimore, Maryland, refinery

added a 150-ton asphalt unit of vacuum type with contract to E. B. Badger & Sons Company. At Ponca City, Continental Oil Company plans early installation of a solvent dewaxing process to finish 400 barrels of dewaxed oil daily.

Crew-Levick Company, Titusville, Pa., during the year installed a new 2000-barrel vacuum distillation system replacing several shell stills.

J. E. Crosbie, Inc., and **Warren Petroleum Company,** Tulsa, erected a new gasoline plant in the Fitts pool, Pontotoc County, Oklahoma, of 20,000 gallons capacity, using Tulsa type absorption and distillation systems.

Crown Central Petroleum Corporation, Houston, is building a new two-stage atmospheric and vacuum distillation unit to replace battery of shell stills. Contract to Alco Products, Inc.

Crown Central Petroleum Corporation, Houston, enlarged steam generation plant, giving contract to Henry Vogt Company for new bent-tube water-tube boiler, 750 horsepower.

Cushing Refining & Gasolne Company, Cushing, Okla., completed an 1800-barrel Dubbs cracking installation of modern type with work done under Universal Oil Products Company supervision.

Danciger Refining Company, Longview, Texas, refinery has again been mentioned in reports as contemplating early construction of a cracking unit. At the Pampa, Texas, refinery the company completed extensive revamping work this year.

Denver Refining Company, Denver, Colorado, erected a 500-barrel refinery to specialize in road oil and fuel oils.

Empire Oil & Gas Company, Burton, Kansas, erected a new stabilization system at natural gasoline plant.

Ralph Fair, Inc., Harlingen, Texas, has completed erection of a 500-barrel skimming plant.

Fern Oil Company, Thermopolis, Wyoming, enlarged refining capacity by installation of new distillation unit, and also added three new boilers for steam generation.

Freedom Oil Works, Freedom, Pa., about the first of September completed a modern Dubbs cracking unit to handle about 500 barrels of gas oil daily, which incorporates some new features. Contract to Leader Industries, Inc.

Freedom Oil Works, Freedom, Pa., installed this summer a Chlorex solvent extraction plant which handles 600 barrels of steam refined stock or 1500 barrels of neutral oil per day. It is the first Chlorex plant handled as a project by an engineering contractor and is four-stage extraction with the necessary distillation and auxiliary equipment. Contract to Leader Industries, Inc.

Gas Oil Products, Inc., Philadelphia, erected a large liquid gas plant at Lucinda, Pa., using a high pressure fractionating system designed and erected by Burrell-Mase Engineering Company.

Gilliland Refining Company, Gladewater, Texas, is said to plan erection of a new natural gasoline plant on a 15-acre site in the W. W. Simms survey, Gregg County, under lease from Tide Water Oil Company.

Gregg-Tex Gasoline Corporation, Longview plant, completed in 1934, added more units, boosting capacity about one third, during recent months.

Gulf Refining Company, Port Arthur, Texas, is installing a 5000-barrel unit of the Furfural refining process, licensed by Texaco Development Corporation. Plant should be completed around October 1.

Gulf Refining Company, Port Arthur, Texas, has installed a 950-barrel installation of Solvent Dewaxing Process (Acetone-Benzol) licensed by Texaco Development Corporation. Plant was completed in June.

Gulf Refining Company is mentioned in reports as planning erection of a new refinery at Curtis Bay, Baltimore, Maryland.

Home Oil Refining Company, Great Falls, Montana, remodeled its refinery, including installation of latest type of Dubbs cracking unit, also stabilizer, absorber and special treating system. Contract to Ralph M. Parsons Company. Cracking capacity 750 barrels daily.

Howard County Refining Company, near Big Spring, Texas, recently enlarged capacity from 1500 to 2500 barrels through addition of pipe still.

Inland Refineries, Inc., Pontiac, Michigan, has completed a 1000-barrel skimming plant for processing Michigan crude.

International Refining Company, Sunburst, Montana, during recent months completed a program of modernization and enlargement of capacity.

Ithaca Refining Company, Ithaca, Michigan, erected 1000-barrel skimming plant. Location is 15 miles north and two east of the Crystal townsite field.

Kanotex Refining Company, Arkansas City, Kansas, rearranged crude oil distillation facilities to secure pressure distillation with revamped Jenkins cracking equipment.

Keystone Pipe Line Company, subsidiary of Atlantic Refining Company, Philadelphia, is completing 180-mile extension to its gasoline line to Pittsburgh from Mechanicsburg, Pa., which will result in shutting down the company's Pittsburgh plant and reduce operations at the Franklin, Pa., refinery.

Lakeland Refinery, Inc., Lansing, Michigan, erected a 1500-barrel refinery, which was completed this fall.

Lone Star Refining Company (Trinity refinery), Gladewater, Texas, completed construction of a new cracking unit, and enlarged capacity to 6000 barrels per day.

Louisville Refining Company, Louisville, Kentucky, during the early part of the year completely revamped Dubbs cracking unit and installed a new double-end fired furnace, with contract to Alcorn Combustion Company.

Los Angeles Refining Company, Bandini Boulevard, Los Angeles, completed a 2500-barrel Southwestern Engineering Corporation skimming plant, starting operations in January, 1935.

Magnolia Petroleum Company, at Luling, Texas, refinery revamped and modernized cracking facilities, including reconstruction of furnace by Alcorn Combustion Company.

Magnolia Petroleum Company, Beaumont, Texas, is completing installation of 30,000-barrel combination skimming and cracking unit to operate under Gasoline Products Company license. Contract to M. W. Kellogg Company.

McClanahan Refineries, Inc., St. Louis, Michigan, completed 1500-barrel refinery in March.

Malco Refineries, Inc., Artesia, New Mexico, recently signed contract with Ralph M. Parsons Company, for a 700-barrel capacity Dubbs cracking unit to cost approximately $150,000. To be completed early in 1936.

Mid-Continent Petroleum Corporation, West Tulsa, refinery placed in operation new 3600-barrel pressed distillate, atmospheric redistillation unit of Foster Wheeler type, early this year, replacing a battery of 20 shell stills.

Midwest Refining Company, Alma, Michigan, is doubling capacity of refinery erected in 1934 through addition of a new distillation unit to increase production of special products from Michigan crude. Contract for original and second unit to Leader Industries, Inc.

Mohawk Petroleum Company, Bakersfield, California, recently completed a new cracking unit, completing modernization program started last year. Cracking capacity 1000 barrels.

Naph-Sol Refining Company, Muskegon, Michigan, recently completed full flashing Dubbs cracking system, 1100 barrels capacity. Contract to Universal Oil Products Company.

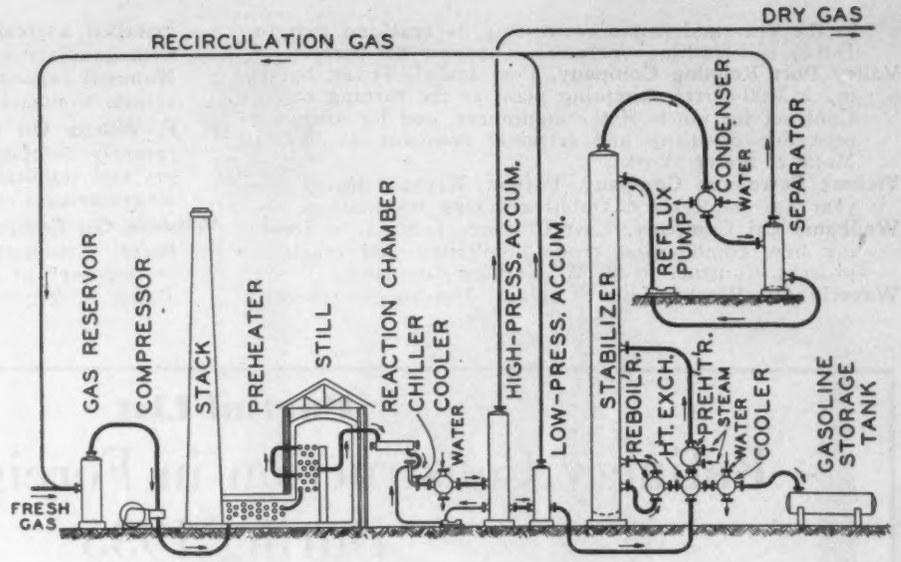
Pan American Refining Corporation, Texas City, has frequently been mentioned in reports throughout recent months as definitely planning doubling plant capacity through erection of a new 30,000-barrel combination skimming and cracking unit. M. W. Kellogg Company erected the original installation.

Panhandle Refining Company, Wichita Falls, Texas, purchased Paragon Refining Company's Leuders, Texas, skimming plant, revamped and enlarged capacity.

The Pennzoil Company, Oil City, Pennsylvania, let contract this summer to Alco Products, Inc., for construction of a modern 4000-barrel pipe still distillation unit.

Pentagon Refining Company, Detroit, Michigan, (Plymouth), erected 1500-barrel skimming plant.

Pettus Oil & Refining Company completed erection recently of 1000-barrel tube still and fractionating column



Flow diagram of polymerization plant handling refinery gas for production of high octane value liquid for blending into gaosline.
Courtesy, Pure Oil Company.

type skimming plant at Mathis, Texas. Contract to Vulcan Steel Tank Corporation.

Premier Refining Company, Greggtown, Texas, recently completed refinery consisting of a 4000-barrel combination skimming and cracking system.

Refinery Export Corporation and Independent Terminal Company, purchasers of the old Pierce Oil Corporation refinery at Texas City, have erected a tube still and fractionator system for skimming plant operation.

Republic Oil Company, Texas City, Texas, refinery early this year erected a 3,000,000 cubic foot absorption type vapor recovery plant and stabilizer, with contract to Burrell-Mase Engineering Company.

Roosevelt Oil Company, Mt. Pleasant, Michigan, this year has enlarged steam generating plant, storage tankage, pump houses and added fractionation facilities.

Sabine Valley Gasoline Company, built an 11-unit natural gasoline plant north of Kilgore, Gregg County, East Texas, with capacity of 30,000 gallons. Engineering work was by Petroleum Engineering, Inc., affiliated with Arthur G. McKee Company.

Seal Beach Refining Company, Seal Beach, California, erected a 1000-barrel skimming plant early in the year.

Shell Oil Company of California, at Signal Hill natural gasoline plant completed major modernization program this year, dealing especially with plant transportation facilities. Work handled by Industrial Engineers Inc., Los Angeles.

Shell Petroleum Corporation, Houston, completed installation of iso-octane and polymerization plant at Houston and current plans call for new cracking facilities and new crude oil distillation unit of large capacity.

Shell Petroleum Corporation, Wood River, Illinois, erected a DuoSol solvent refining unit under license with Max B. Miller Company, and contract to The Lummus Company, a large propane dewaxing system, a 20,000,000 cubic feet absorption system, a 12,000,000 cubic foot stabilizer system, and a Dubbs combination type crude distillation and cracking unit.

Shell Petroleum Corporation, Wood River, Illinois, is erecting a new stabilizer with capacity of 6000 barrels to operate in conjunction with T.V.P. cracking unit and a new absorption system to handle 20,000,000 cubic feet of gas daily. At the Houston plant, the company is erecting a new crude prestabilization system with capacity of 44,000 barrels daily. Contracts to Alco Products, Inc.

Shoreline Oil Company, Lewis, (mail address Vivian), Louisiana, made improvements by adding Sharples centrifugal dewaxing process and acid treating plant early in the year. Recently the company made further additions by adding fractionating facilities, new condensers and automatic canning plant for lube oils.

Skelly Oil Company, El Dorado, Kansas, during the summer months, modernized the crude still, adding fractionating columns, rebuilding condenser system and reconstructed furnaces.

Solvex Refineries, Inc., Gladewater, Texas, is building a modern Dubbs cracking unit, capacity 1500 barrels. Contracts to Frick-Reid Supply Company and Burrell-Mase Engineering Company.

Standard Oil Company of California completed $2,250,000 improvement program this year, which involved erection of a combination atmospheric and vacuum distillation unit, a major program of modernization of cracking units, solvent treating system, gasoline recovery unit, stabilizer, lubricating oil vacuum type rerun unit, wharfage facilities and booster plant.

Stone Oil Company, Texas City, Texas, recently completed improvements involving erection of a new tube still for viscosity breaking service.

Sullivan City Refining Company, Sullivan City, Texas, completed recently new 1000 barrels skimming plant.

Sunray Oil Company, Allen, Oklahoma, completed modernization program in January when new recovery plant and stabilizer started operating. Previous work consisted of a new Dubbs cracking unit.

Tide Water Oil Company, Bayonne, N. J., during the summer completely rebuilt and enlarged gasoline recovery plant and stabilizers.

The Texas Company at Port Arthur refinery is building a 3000-barrel installation of the Solvent Dewaxing Process (Acetone-Benzol process), licensed by Texaco Development Company. The Texas Company, at the same refinery has under construction a 4000-barrel installation of Furfural refining process, also licensed by Texaco Development Corporation.

The Texas Company at Port Arthur is including in modernization program plans for erection of a new combination skimming and cracking unit at reported cost of $850,000. The company also recently enlarged asphalt plant at Port Neches.

Texas Carbon & Gasoline Company was formed during the summer by Danciger Oil & Refineries, Inc., to erect a 50,000,000 cubic foot gasoline plant and carbon black plant of sufficient capacity to handle residue; near Oil City, southwestern Hutchinson County.

Texas Oil Products Company, Gladewater, Texas, tore down and reconstructed a crude oil distillation unit, enlarging plant capacity to 3500 barrels per day.

United Carbon Company, Charleston, West Virginia, erected a 25,000,000 cubic foot carbon black plant in southwestern Hutchinson County, Texas Panhandle, to burn residue from Phillips Petroleum Company.

United Refining Company, Warren Pa., signed license agreement with Universal Oil Products Company early

in the year and began converting its cracking unit to Dubbs full flashing operation. Capacity 400 barrels.

Valley Port Refining Company, Port Isabel, Texas, building a 5000-barrel skimming plant at the turning basin. Contract for much of the equipment, and for affiliated pipe line company and terminal company to Wyatt Metal & Boiler Works.

Vickers Petroleum Company, Potwin, Kansas, during the year has modernized Dubbs cracking installation.

Wadhams Oil Company, East Chicago, Indiana, is erecting new combination crude distillation and cracking process. Contract to M. W. Kellogg Company.

Waverly Oil Works, 54th St. plant, Pittsburgh, recently installed a steam atmospheric topping and lube unit with auxiliary column for special products production. Nominal capacity 1200 barrels but operates at higher rating. Contract to Leader Industries, Inc.

H. F. Wilcox Oil & Gas Company, Bristow, Oklahoma, recently completed modern combination vapor recovery and stabilization system. Contract to Burrell-Mase Engineering Company.

Wilshire Oil Company, Los Angeles, is erecting a 12,000 barrel combination skimming and cracking (Dubbs) installation, at Santa Fe Springs, with contract to Ralph M. Parsons Company.

Partial List

Refinery Construction in Foreign Countries During 1935

Administracion Nacional de Combustibles, Alcohol y Portland, Montevideo, Uruguay, 3000-barrel distillation unit and modern full flashing Dubbs cracking unit now being installed. Contract to Foster Wheeler Corporation. Cracking capacity is 1200 barrels daily.

Anglo-American Oil Company, at Ellesmere Port, England, has under construction a complete refinery for the manufacture of specialties in addition to usual petroleum products.

Amtorg Trading Corporation, New York, has given contract to Alco Products Inc. covering equipment for a 12,000-barrel refinery at Ufa, Baskkirian republic in Southern Urals, U. S. S. R. Plant includes facilities for topping, cracking, reforming and treating.

Anglo-Iranian Oil Company, Abadan, Iran (Persia), let contract during the summer to E. B. Badger & Sons Company for construction of the world's largest topping and vacuum distillation unit, with capacity of 60,000 barrels daily. Company is also erecting a 12,000-barrel stabilization system.

Appolo Rafineria Mineralnych Olejov Ucastinarska, Spolocnost, Bratislava, Czechoslovakia, is building a new 1100-barrel Dubbs cracking unit with contract to Skoda Works, of Prague.

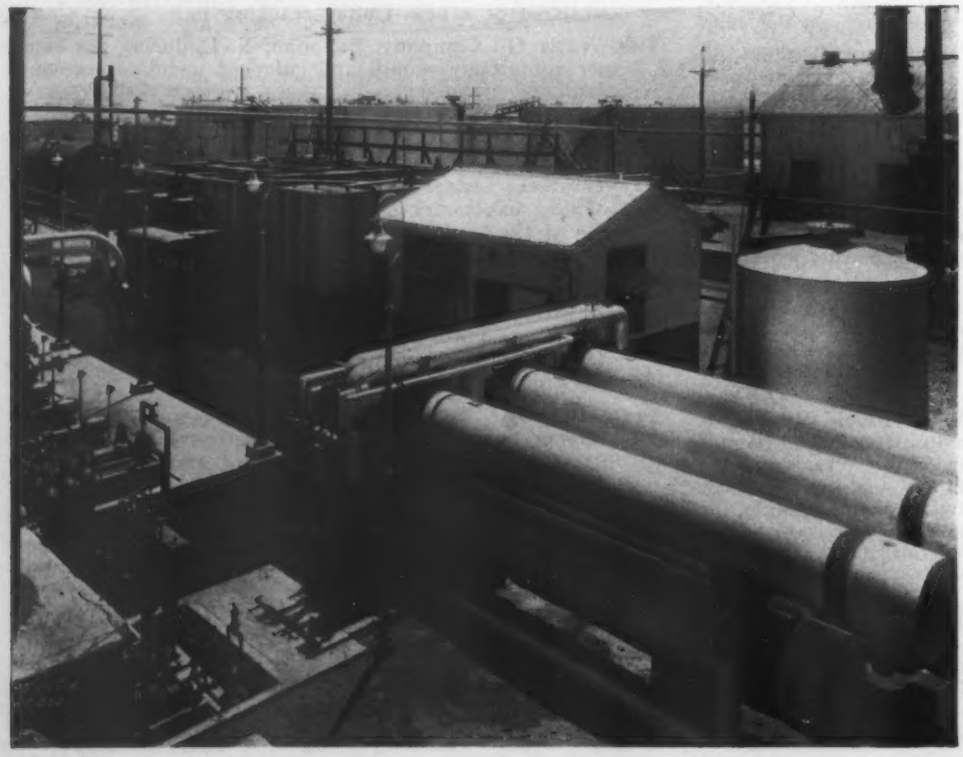
Arend Petroleum Company, subsidiary of Canadian Eagle Oil Company (Shell), at Aruba, West Indies, enlarged distillation facilities and expanded Dubbs cracking battery, purchasing large pressure vessels from A. O. Smith Corporation. Work is not yet completed.

Asiatic Petroleum Company, with refinery construction project in Java, East Indies, gave contract to Arthur G. McKee & Company, purchasing in this country 175 tons of steel plates, shapes and bars.

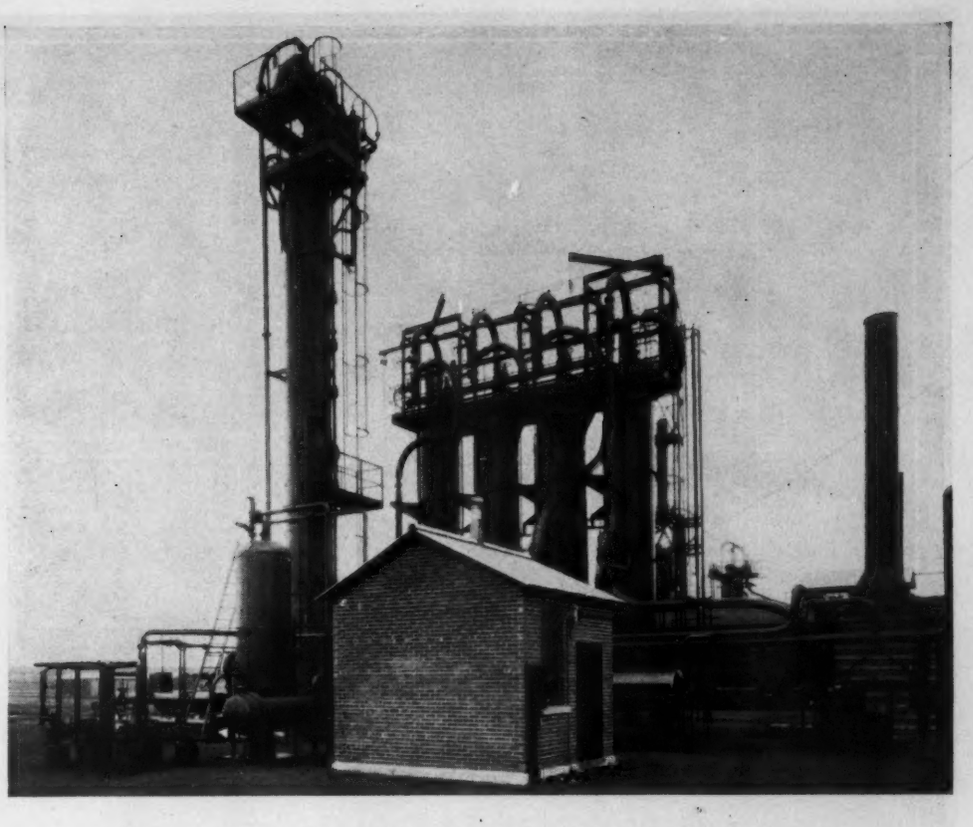
Asiatic Petroleum Company, during the year, erected a 15,000-barrel vacuum distillation unit at Curacao, D.W.I. Contract to E. B. Badger & Sons Company.

Assam Oil Company, Digboi, India, is erecting a 600-barrel Dubbs cracking unit or modern type, with construction work under supervision of Universal Oil Products Company.

Azienda Generale Italiana Petroli (A. G. I. P.) Mestri, near Venice, Italy, has rebuilt and enlarged distillation and Dubbs cracking capacity. Contract to Foster Wheeler Corporation.



Heat exchanger system, part of controls, tanks and piping employed in conjunction with propane dewaxing process.
Courtesy,
Foster Wheeler Corporation.



Cracked gas polymerization plant. At the extreme right is the gas heater. In the foreground is the control house. Back of it the four catalytic polymerization towers, and to the left of them the polymer gas stabilizer.
Courtesy,
Universal Oil Products Company

Bell Refining Company, Calgary, Alberta, Canada, double capacity to 1500 barrels through installation of semi-cracking unit and other distillation equipment.

Canadian Oil Companies, Ltd., Petrolia, Ontario, Canada, completed construction of new $425,000 refinery, which includes skimming, cracking unit, gasoline recovery system generator plant and regular auxiliaries. Company is subsidiary of National Refining Company.

Comet Oil Refineries, Ltd., Montreal, Quebec, Canada, is installing a 2700-barrel topping plant and a modern Dubbs cracking process of 2280 barrels capacity. Contract to Geo. A. Fuller Construction Company.

Consumers Refineries Cooperative Association, Regina, Saskatchewan, Canada, awarded contract to North West Iron Works, Regina, for construction of skimming plant.

Creditful Minier, S. A., Brazi, Roumania, is completing a 3500-barrel cracking-reforming Dubbs process unit, with contract to Bruno-Kralovo Pole, Czechoslovakia. Same company in connection with the Dubbs unit is installing the Gray process for vapor phase treating of the cracked gasoline.

Curacaosche Petroleum Industrie Maatschappij (Shell Oil Company) Caracao Island, West Indies, during this year has incompleted a large program of expansion of both skimming and cracking facilities. This company uses the Dubbs Cracking process and reports have been published to the effect that 11,000 barrels of new capacity has been added during recent months.

Herbert Green Company, Ltd., Ellesmere, England, is installing 950-barrel Solvent Dewaxing Process (Acetone-Benzol) under license from Texas Development Corporation. To start operating in October. Same company earlier completed installation Duo-Sol unit, under license from Max B. Miller Company, with contract to The Lummus Company.

Irac Petroleum Company recently let contract to Foster Wheeler Corporation for construction of a large crude oil pre-stabilization plant near the Kirkuk field. Included are facilities for removal of fixed gases and hydrogen sulfide.

Lago Petroleum Corporation, Aruba, D. W. I. during this year has been engaging in an important program of expansion affecting both distillation and cracking.

Lloyd Refineries, Ltd., Port Credit, Canada, is erecting a modern Dubbs cracking installation with rated capacity of 900 barrels per day.

"NITAG" Petroleumhafen, Germany, built an 8000-barrel combination skimming and cracking unit, with contract to Winkler-Koch Engineering Company. Lachman treating system, vapor recovery and stabilization equipment.

Pierce Oil Company, S. A. (Consolidated Oil Corporation) at Tampico, Mexico, completed a new 1200-barrel topping unit and an asphalt reducing unit, early in 1935.

Raffineries, Vacuum, Naples, Italy, is building complete 3000-barrel refinery.

Royalite Oil Company (Imperial Oil Company) built a second natural gasoline plant in the Turner Valley field, Alberta, Canada.

Shell-Mex & B. P. Limited, at Shell Haven, England, is building a 1200-barrel installation of the Solvent Dewaxing Process (Acetone-Benzol) licensed by Texaco Development Company.

Shell-Mex & B. P. Limited, Shell Haven, England, building a 1600-barrel per day unit Furfural refining process, licensed by Texaco Development Company.

The Shell Company of Palestine, controlled by Consolidated Petroleum Company (Anglo-Iranian Oil Company and Asiatic Petroleum Company) completed erection of a refinery at Haifa, Palestine, on the terminus of the Irac Pipe Line's southern branch. Capacity 180,000 tons per year.

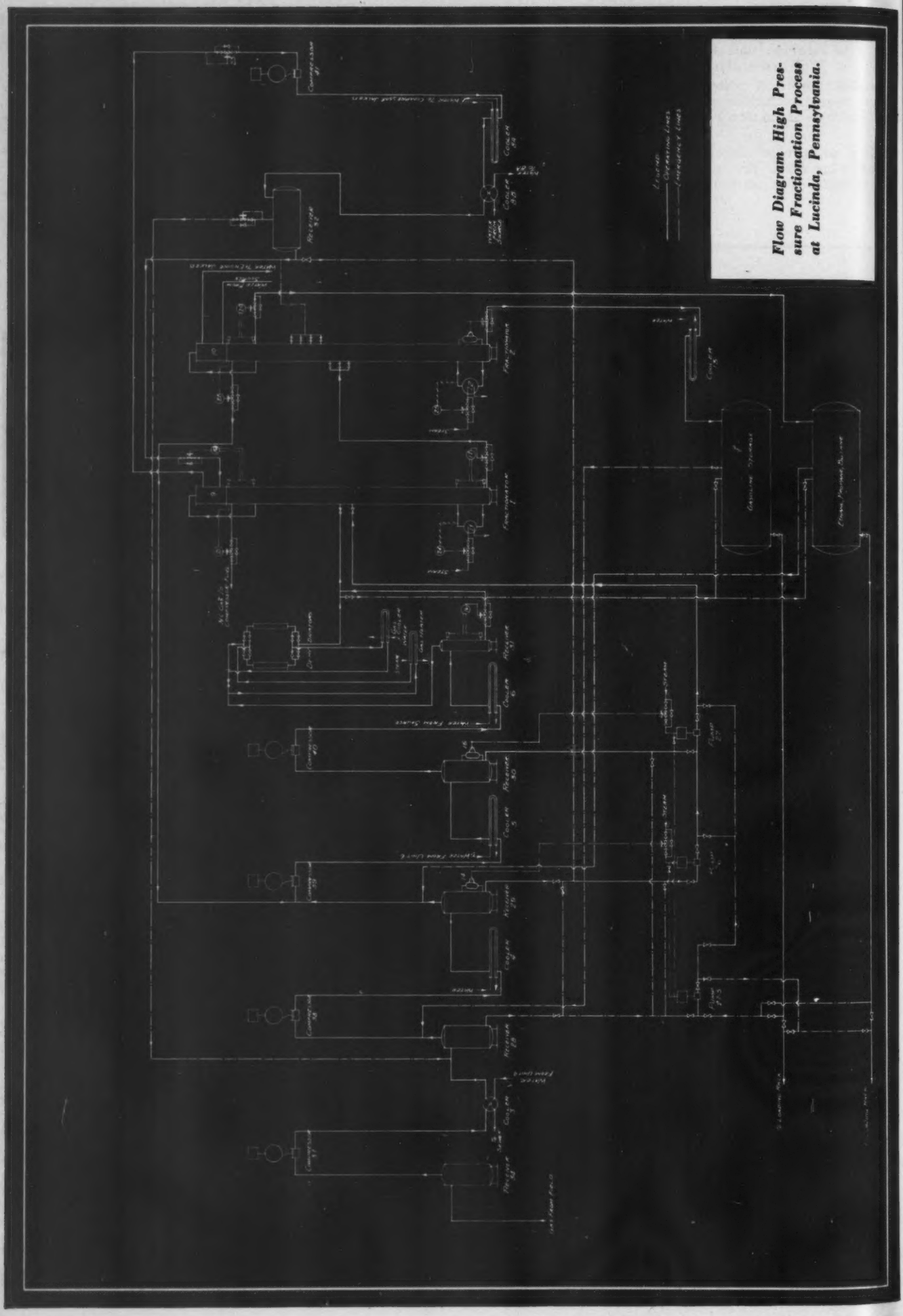
Societe Lyonnaise des Schistes Bitumineux, Les Telots, France, will soon complete erection of a modern 500-barrel Dubbs cracking unit. Contract to Chantiers-Loire, Paris, France.

Socony-Vacuum Oil Company, Inc., refinery at Bremen, Germany, is installing a unit of Solvent Dewaxing Process (Acetone-Benzol) with capacity of 500 barrels per day. Under license from Texaco Development Corporation.

South Manchuria Railway Company, Fushun, Manchuria, is erecting a new Dubbs cracking unit with capacity of 850 barrels per day. Work under supervision of Universal Oil Products Company.

Standard Oil Company of California, operating as Standard Oil Company of British Columbia, Canada, is building a 2500-barrel refinery at New Barnaby. Contract to Alco Products, Inc.

Trinidad Leaseholds, Trinidad, has been engaged in the installation of a new 10,000-barrel topping plant.

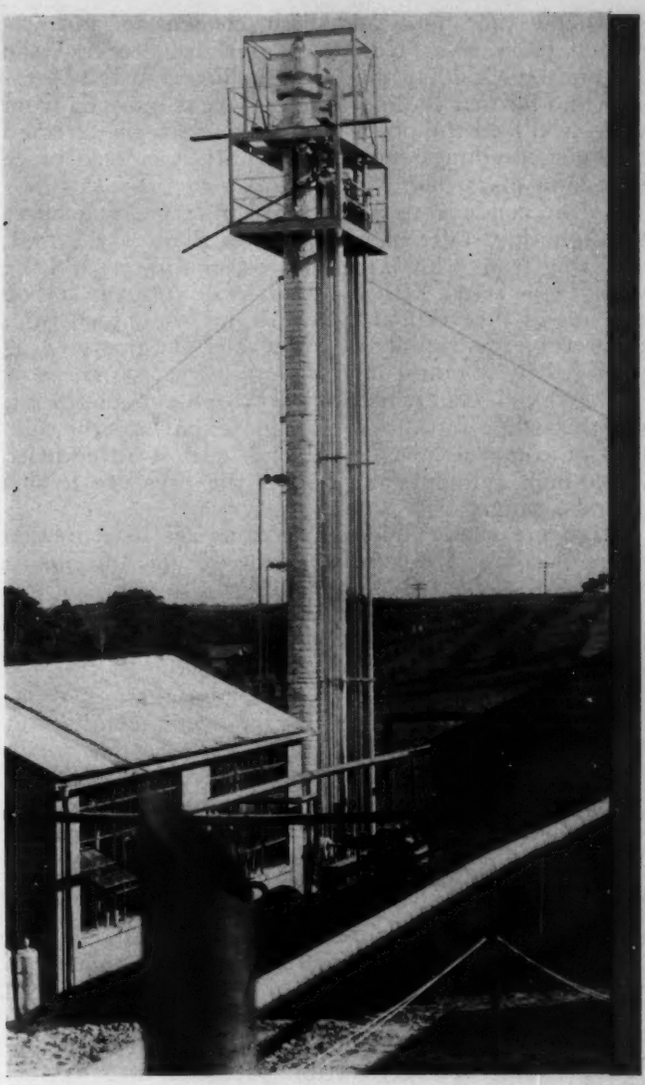


Flow Diagram High Pressure Fractionation Process at Lucinda, Pennsylvania.

Design of High Pressure Fractionation Process

At Lucinda, Pennsylvania

JOHN ALBRIGHT



ONE of the most interesting plants built for super fractionation is located at Lucinda, Pennsylvania, a few miles from Clarion. This plant, which has been in operation for only a few weeks, fractionates and separates ethane, propane, butane and heavier hydrocarbons. The fractionation is handled in such a manner that commercially pure ethane may be cut as an overhead product, while the heavier fractions, propane and other hydrocarbons, are removed as a base cut. The plant was designed by Burrell-Mase Engineering Company to handle the raw gas being produced from the third sand in this vicinity. The gas yields about three to four gallons per thousand feet when running to include propane and heavier.

The plant is located on an old refinery site, near the wells from which the gas is taken. Vacuum lines connect with the wells, some of which are oil producers, but the majority produce only gas. Vacuum is necessary to draw this gas from the wells to the plant. To secure the necessary degree of vacuum on the field lines, and to boost the pressure on the gas, five 80-horsepower gas engine-driven compressors are used. The first unit is equipped with a 26 x 20-inch vacuum cylinder, which maintains about 25 inches of mercury vacuum on the intake scrubber.

The gas, which does not carry the oil fractions in large proportions, is scrubbed in a small cylindrical vessel near the plant, from which it passes to the intake header to the engine. It is metered through a master meter with the recorder unit placed in the pump and control room. About 500,000 cubic feet of gas is being pumped in from the field, handled by the compressor number 37. (See flow chart—Figure 1.) From a vacuum of about 25 inches of mercury—the intake varying from that figure to as low as 28 inches—the gas is boosted to about five pounds pressure, gauge, and cooled.

Each stage of compression throughout the plant operating cycle is cooled in individual coolers before being taken into the suction of the succeeding engine. The cooler sections are individual units, which use water for the heat reducing medium. The exchanger, or gas cooler serving the discharge of intake unit No. 37, is designated as cooler No. 3, which makes use of water from the succeeding exchanger, and after the water has passed through and cooled the discharge from the vacuum pump, it is discarded.

After the gas has been passed through this exchanger, it enters receiver No. 28, where all gasoline which may have been condensed in cooler No. 3 is separated from the gas. Water vapor reduced to liquid is also dropped out in this receiver and may be drained to the sewer with other wastes. Immediately after the low pressure gas enters receiver No. 28, compressor No. 38 takes suction. This compressor, an 80-horsepower gas engine, has 14 x 20-inch cylinder, and the gas is compressed to about 200 pounds.

This gas also is cooled in an exchanger, which is a

shell and tube unit and both condensate and gas passed to receiver No. 29. Water used to cool the gas and knock down the fractions liquid at that pressure and normal cooling temperature is pumped from water wells on the property. As this water is directed to the succeeding condenser, or unit, it is used twice only, and discarded.

As the condensate is produced in larger quantities through this stage of compression than in the first, or lifting from a low vacuum to a small pressure, the receiver is fitted with a liquid level control, set on the side of the vertical tank. Liquid is pumped from this receiver as rapidly as condensed, the pump being operated by a liquid level controller set on the side of the vessel. Gas which has not been condensed under this stage of compression is taken into the suction of compressor No. 39. This unit is fitted with 7 x 20-inch cylinder, and boosts the pressure to 500 pounds, gauge.

High pressure condenser sections are used in this stage of compression, being made of pipe, one inside the other, stacked six sections high. Liquids and gas are received in a vertical unit, receiver No. 30, from which the liquid is removed as from the preceding unit. Gas is taken directly from the top of this accumulator into the last stage of compression. Compressor No. 40 is an 80-horsepower machine, but fitted with a high pressure gas cylinder, having a bore of 4½ inches and a stroke of 20 inches. Here, the gas is compressed to that pressure desired, the unit being capable of boosting the pressure to as high as 2000 pounds, gauge. An operating pressure of 1500 pounds is used when the plant is adjusted to condense ethane.

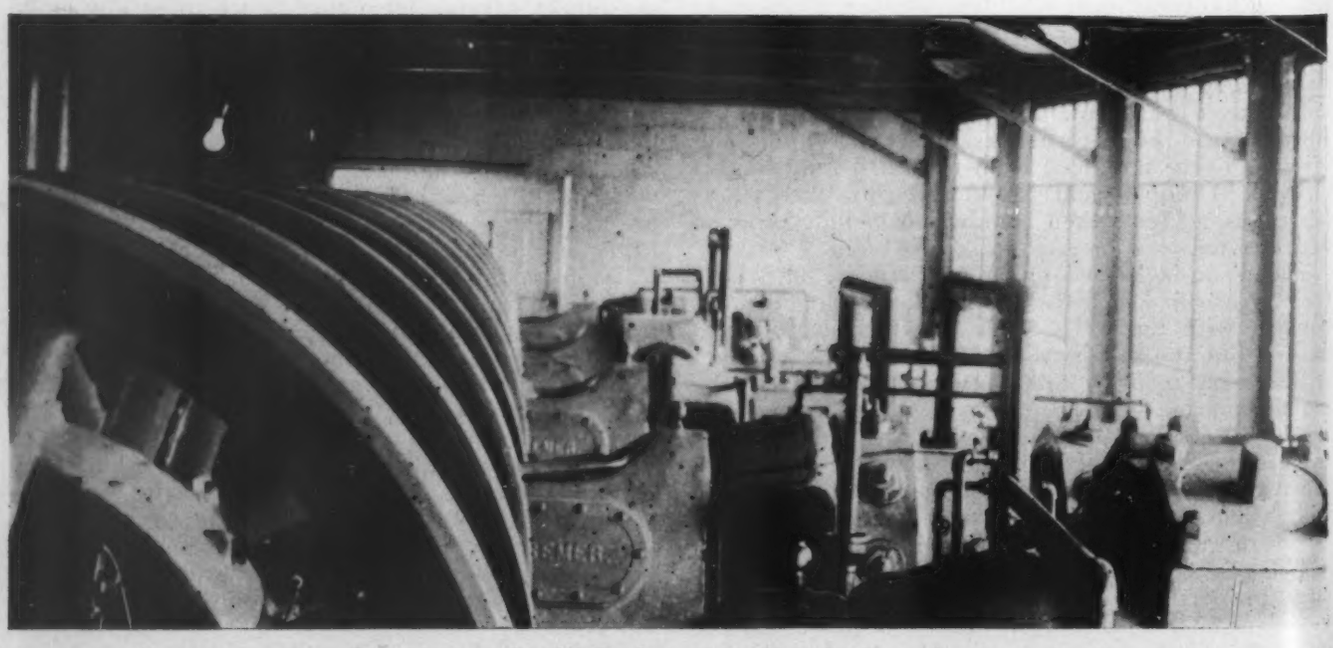
The gas and condensates are passed through cooler No. 6 which is cooled with water. Two thousand-pound working pressure fittings and valves are fitted on this unit, with heavy gauge glasses and fittings so the operator can determine by sight the level of the liquid in the receiver. High pressure forged steel valves also are used, which are marked for 2000 pounds working pressure. Liquid is vented from this receiver through an automatic float controller, operating a diaphragm valve on the liquid line.

The liquid vented from this receiver, unit No. 31, is fed under process pressure to the first-stage fractionation unit, fractionator No. 1. Two of these columns are used in this plant, both being high pressure columns welded in the shops and stress relieved in normalizing ovens after fabrication. The condenser section on the first, or higher pressure unit, is made up of shell and tube type cooler and is operated at the desired temperature to obtain fractionation. The temperature, reaching in some operations, as low as minus 100°F., is obtained by expanding liquefied propane into the cooling side of the tubes.

The operation of this and the succeeding fractionator, unit No. 2, is variable, because of the results desired. Usually, temperatures sufficient to liquefy ethane and heavier hydrocarbons are maintained on the cooler section, which permits only methane to escape through the vapor line. If only propane and heavier fractions are desired in the base product, the temperatures are adjusted so methane and ethane both are taken from the overhead vapor line. The method of operating this fractionator is governed by the demand for liquefied products.

Uncondensed gas from receiver No. 31 is removed through an overhead line, and it may be passed through a gas cooler or a gas heater, as the method of operation demands. After passing through either of these units, the gas is led to a high pressure dehydrator. This dehydrator is made up in the form of a double unit, either of which may be used. A moisture removing agent (silica gel) is placed in the small cylinders which are drop forgings, and the one selected for operation is used on the line for about 10 hours, after which the gas is passed through the other, a similar unit. While the second unit is being used, the first one is steamed out with superheated steam to drive out all moisture selected from the gas. About two hours are required to cool the unit after steaming so it can be used again. These units are small, being about six inches, outside diameter, by about 16 inches in length, insulated to maintain the desired working temperature.

Heavy forged steel fittings and valves are used on these units to make up the manifold to withstand high pressures while in operation. When steam is used to dry out the silica gel, the pressure is of



Engine room, Gas-Oil Products, Inc., Lucinda, Pennsylvania

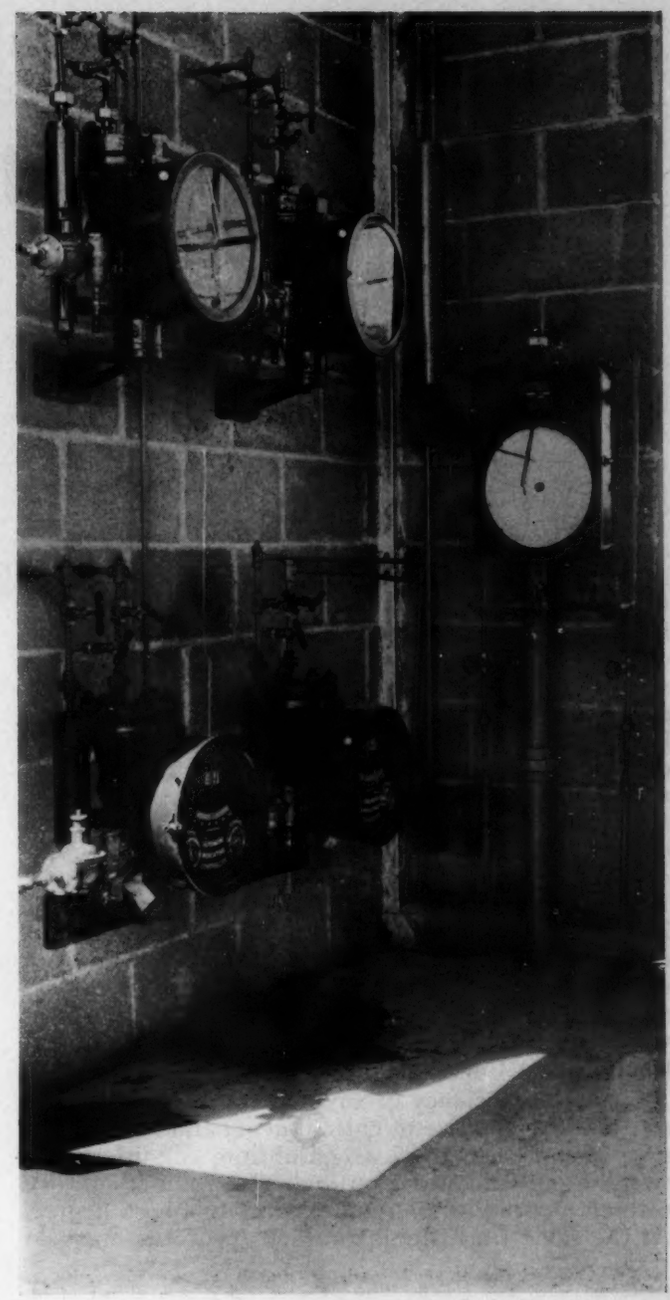
course much less, but high pressure block valves also are placed on the steam line connections to prevent gas leaking back into the lines from the boilers. This gas is introduced into the fractionator together with liquids condensed and trapped by receivers Nos. 28, 29, and 30. The gasoline is handled by special outside piston packed pumps, two of which are set, one as a spare, have a bore and stroke of 1¾ by 12 inches and the fluid end is made from one piece of drop forged steel. The other pump, of similar construction has a bore of 1¼ inches and a stroke of six inches. The liquid handled by these pumps is fed to them through liquid level controllers, operating steam valves on the line leading to the power cylinder.

As the operating phase of this column is determined by the products desired, steam is used in a reboiler at the base of the fractionator to maintain the desired temperature. Reflux is made up and governed by the overhead condenser temperature, which separates the undesirable fractions from those falling back through the column to the base. As both columns are operated in series, the liquefied gases and natural gasoline as a composite mixture is transferred automatically from the base of fractionator No. 1 to No. 2. Liquid level controllers on these columns maintain a predetermined level, and the liquid from the first is fed through a diaphragm valve which floats on the stream. The gas which is not condensed is led to a fuel system which furnishes gas to the engines and boilers.

The second fractionator is almost identical in construction with the first, but the overhead condenser is operated by pumping water through it instead of liquefied gases. In process of fractionation the gasoline and liquefied gases are fed to one of three nozzles placed about mid-way of the shell of the column. By adjusting the operation of the column, two cuts are taken from this fractionator. The overhead cut may be ethane, propane or butane, as the case may be. Since only two columns are in operation, separation of the liquids into more than two fractions is not possible without re-running the base product. However, two other columns are being fabricated, which will permit continuous fractionation without rerunning any portion of the liquid.

Propane, commercially pure, is taken off the overhead vapor line on the second fractionator and passed to a surge tank which is placed in the plant control room. This liquid is used as the refrigerant to operate the condenser section on the first fractionator. It is passed to the shell and tube unit and released through an expansion valve at the top of the column. This is a thermostatically operated unit, controlling the temperature to that desired by regulating the amount of liquid expanded to the unit. Vapors from this unit are returned to compressor No. 41, which is placed in another building away from the main engine room. The vapors are reliquefied and accumulated back in the accumulator, or receiver No. 32. This liquid is recycled and when losses occur, "make up" is taken from storage tanks in the plant. If vapors generated in this receiver are such that pressures above that desired are generated, excess gases are released through a suitable line and taken in with the suction on compressor No. 38 and recycled, or reprocessed through the plant.

If the operation of the second fractionator is such that propane only is desired, excess gases, ethane and lighter, are vented from the top of the column and led back to one of the compressors, No. 39, and



Control Station

passed back through the plant. If butane is desired, after the propane is extracted, the batch is taken through the second fractionator in about 20,000 gallon amounts and reprocessed for the fractions desired. In the usual run of the plant, ethane, propane and butane are taken as an overhead cut, with the pentanes and heaviers accumulated in the base of the column and vented from there to the storage tanks.

While this plant was placed in operation July 20, and has been in operation only a short while, enough is known of its possibilities that the company has begun the erection of additional compressors and other equipment to increase capacity from 500,000 cubic feet to about 2,000,000 cubic feet. Gas will be processed through the expanded plant so that any fraction may be taken off in process at the desired point without the necessity of rerunning. Storage has been built which will accommodate the handling of high pressure liquids together with sufficient storage for the more stable gasoline.

Efficiency of Petroleum
Fractionating Columns

PART III

A Study of Laboratory Packed Columns

C. W. CANNON*
Shell Petroleum Corporation, Houston, Texas
and
R. L. HUNTINGTON
School of Petroleum Engineering, University of Oklahoma

IN a previous communication[3] a description of a true boiling point distillation column was given, along with sample calculations and graphs showing its capacity and efficiency under several different rates of product removal. The importance of the laboratory column and its relation to the unit process of distillation is readily realized when one observes the great amount of work which is being done along this line at present. Fenske and his coworkers[2] have studied various factors such as different types of packing, column height and diameter, distillation rate, all in their relationship to H. E. T. P. (Height Equivalent to a Theoretical Plate). Podbielniak[4] has contributed much toward the knowledge of the design and operation of true boiling point columns. He has stressed the importance of the prevention of hold-up in small laboratory towers especially when close cuts are being made. Further work has been undertaken in this laboratory in an attempt to find an efficient packed column which may serve as a measuring stick in the analysis of a commercial size fractionating tower. (Figure 1).

Since the efficiency of any column is based largely on: (1) The absence of entrainment; and (2) The degree of approach toward equilibrium conditions between liquid and vapor on each plate, the laboratory column must fill these requirements to a high degree. At the same time, the laboratory apparatus must do its work in a reasonably short time to be of any utility in commercial practice.

Mixtures of commercial fractions of normal hexane and normal heptane were studied in the laboratory since this apparatus was to be used later in determining the efficiency of a refinery tower. In Figure 2, the true boiling point distillations of hexane and heptane fractions are shown. Although these fractions are by no means pure hydrocarbons they have a narrow range for commercial products which are sold in large quantities as solvents. A 50-50 (by volume) mixture of the hexane and heptane was distilled in the high temperature true boiling point column at the rates of 2 c.c. and 5 c.c. per minute. Glass cylinders consisting of tubing ranging from ⅛-inch to ⅜-inch I.D., in ½-inch lengths were used as the packing material. The length of the packed section was 5 feet. A glance at Figure 3 shows that the rate of product removal is an important factor in close fractionation.

Since the glass cylinders held up such large quantities of liquid at the end of each run, No. 18 iron wire helices were tried in an effort to correct this difficulty, but the results were not as satisfactory as expected. The helices were ¼-inch to ⅜-inch in diameter and ½-inch in length, and contained from two to four spirals each. The voids measured 90 percent after the helices were packed into the 1¼-inch I.D. glass column. Very little free space ap-

*Mr. Cannon was an undergraduate student at the University of Oklahoma when this material was prepared and it was a part of his undergraduate Thesis for 1935.

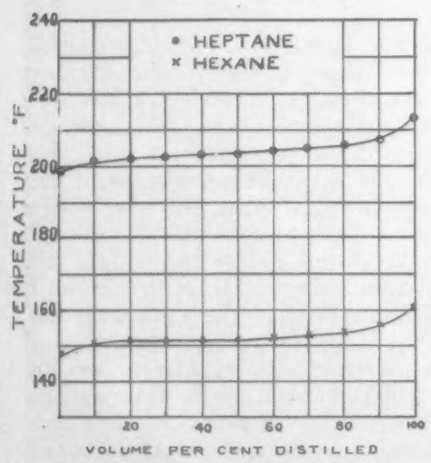


FIGURE 2
True boiling point distillations of commercial hexane and heptane fractions. 1.25 in. I.D. x 5 ft. column.

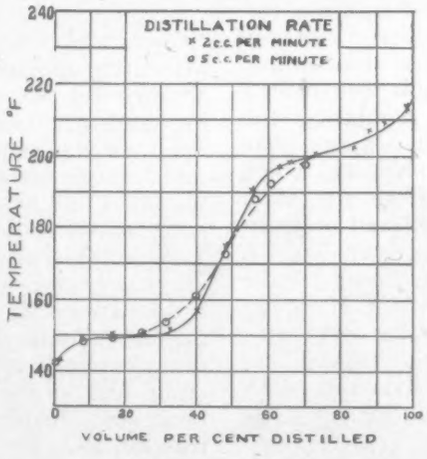


FIGURE 3
True boiling point distillations of 50%-50% (by volume) hexane-heptane mixtures. Packing—Glass cylinders 1.25 in. I.D. x 5 ft. column.

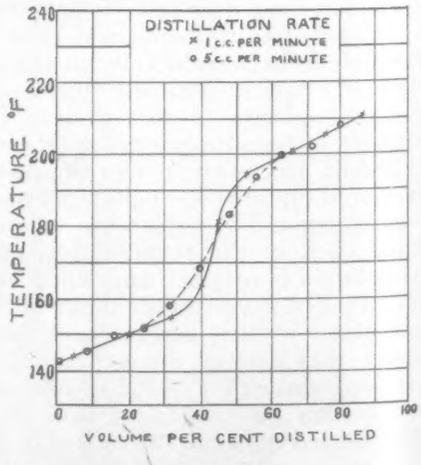


FIGURE 4
True boiling point distillations of 50%-50% (by volume) hexane-heptane mixtures. Packing—Iron wire spirals, 1.25 in. I.D. x 5 ft. column.

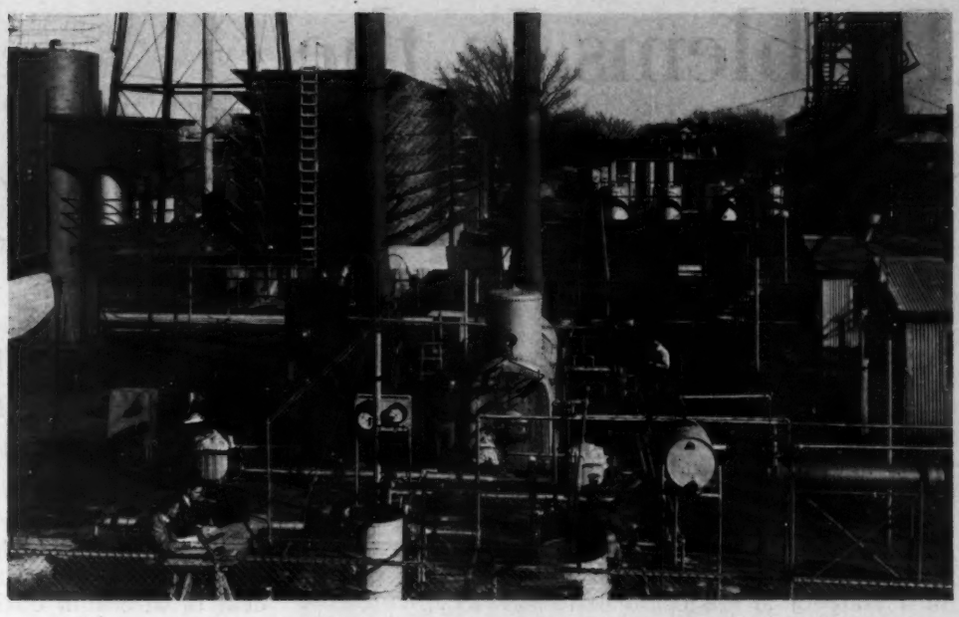


FIGURE 1

Base of 3 ft. x 90 ft. refinery column in right background. Engineering students in foreground, are making a test on insulated and uninsulated oil field boilers.

peared to be present adjacent to the inside walls of the glass column, where channelling might otherwise have occurred. Figures 4 and 5 give the results of four distillations carried out at different rates on this five-foot wire helices' packed column. Comparison of these curves with those obtained on the same column packed with glass cylinders (see Figure 3) indicates that the relative fractionating efficiencies of the two packings are of the same order of magnitude. The wire helices have the advantage in that they *hold up* less liquid during the distillation, and also at the end of the run.

HEMPEL COLUMN

The time factor is always an imporant one in any commercial laboratory, therefore a study was made on a Hempel column having an inside diameter of one inch and a height of six inches. This column was packed with iron wire helices similar to those used in the five-foot tower. Because of less hold-up in this short Hempel column smaller charges could be distilled at as slow a rate as one c.c. per minute in much less time than the larger charges could be run off at two to three c.c. per minute in the five-foot column. Figure six gives the results of a distillation of a 50-50 (by volume) mixture of benzene and toluene, made at the rate of one c.c. per minute. From these data, a McCabe-Thiele vapor-liquid equilibrium diagram has been constructed (Figure 7), showing that the Hempel column had 2.9 theoretical plates when operated at one c.c. per minute and at substantially infinite reflux ratio, i.e., reflux to product. This gives the Hempel an H. E. T. P. (Height Equivalent to One Theoretical Plate) of 2.07 inches.

In the next issue of THE REFINER, an analysis of a commercial size petroleum fractionating column will be given, in which the Hempel column distillations are used as a basis for determining the efficiency of a refinery tower.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Skelly Oil Company for the donation of the hexane and heptane cuts; and to Messrs. W. A. Pearce and Joe E. Johnson who helped obtain some of the distillation data.

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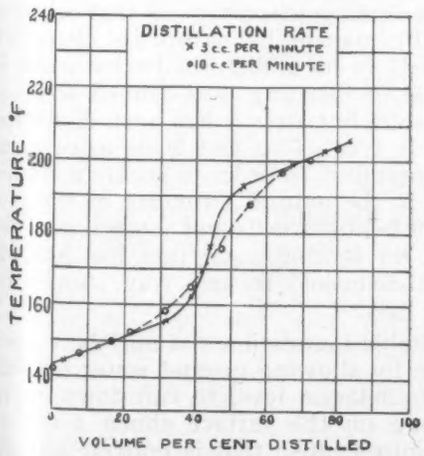

FIGURE 5

True boiling point distillations of 50%-50% (by volume) hexane-heptane mixtures. Packing—Iron wire spirals. 1.25 in. I.D. x 5 ft. column.

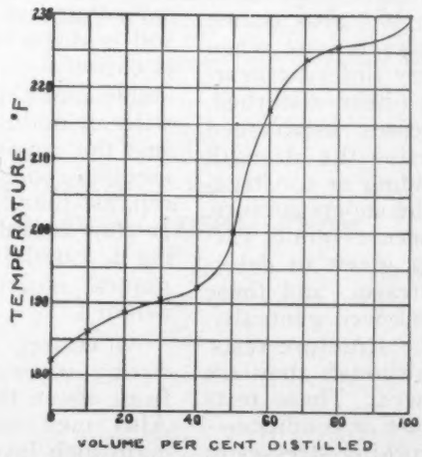

FIGURE 6

Hempel distillation 50%-50% (by volume) benzene-toluene mixture. Packing—Iron wire spirals.

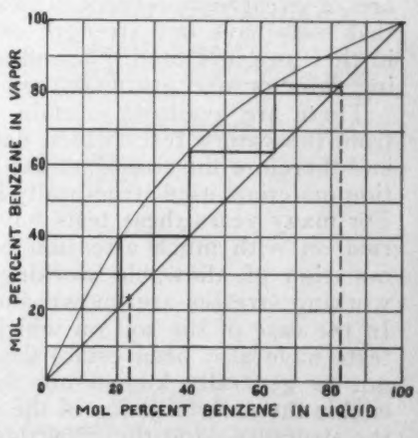

FIGURE 7

McCabe-Thiele diagram of a benzene-toluene mixture showing the number of theoretical plates in a 6-in. Hempel column.

Problems In the *Design of Foundations*

WILLARD E. SIMPSON

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NOT so many years ago even construction engineers looked upon a foundation as so much concrete and steel, or so many piles driven into the ground to certain depths. At present there are innumerable patented types of foundations and many kinds of intricate systems for arranging the steel and concrete. And with it all, apparently very little thought is given to that on which the concrete and steel must rest. (It may not be generally known that soil can be in a state of stress from 50 to 100 feet below the point of application of the foundation load; that this stress is not uniformly distributed under the footings; that a layer of soft mud or quicksand 20 feet below the footing level may seriously increase settlement; or that an adjacent structure can have a marked effect on the settlement of a new structure). Yet these factors and many others materially affect the settlement of any structure placed on soil. The depth to which a foundation footing is extended should never be determined by guess work in an office without complete investigation and examination of the soils under the proposed structure by means of test pits.

The problems of foundation engineering is not so much that of designing a certain foundation in such a manner that the stress in the concrete and steel are not more than the allowable amount already established as it is to determine: First—the nature of the soils under the proposed structure. Second—to select out of these that suitable soil which will remain in the state found throughout the life of the structure. Third—to determine the carrying capacity of the soil selected.

ACTION OF SOILS

Scientific research into the action of soils has proved beyond doubt that the conditions in question are of great importance. Research has also shown that soils have one strength or characteristic when in their original condition and a very different bearing value or strength after they have been disturbed.

There are available certain stresses established from laboratory tests which determine the strength and therefore the size of all the building or construction materials used structurally in the superstructure. For many years these tests have been carefully carried on with much attention being given to determination of allowable working stresses, and these working stresses are known and followed generally. In the case of the soil on which the structure rests, tests have also been established, although they are not so generally known nor followed. These tests enable the determination of the nature or condition—the structure—and the allowable working stresses in the soil.

It should be realized that the foundation of a structure is the soil itself and that its classification and action, and its characteristics under load, are the determining factors in the building of a safe foundation. The science of soil mechanics has received a great deal of attention during the last six years, notably since Charles Terzaghi, M. Am. Soc. C. E., prepared his treatise on the "Science of Foundations," which was published in the Transactions of the American Society of Civil Engineers, Volume 93, 1929. Since then, laboratory methods have been developed whereby soils can be properly sampled, their action under stress studied, and their classification determined. However, the more laboratories study the science, the more involved it becomes. The mechanics of soils is really a science of great magnitude and scope and worthy of the efforts of the most able engineering minds.

Reference will be made here only to the several types of plastic clays, since well-compacted sandy clays or sandy soils cause little trouble when more or less confined. Sand, of course, is the very best foundation material and is generally an unyielding one. Excessively sandy clays also form stable, unyielding foundations and are not easily disturbed. In Texas it has been found that most foundation troubles are caused by plastic clays. There is no difficulty in using rock, hardpan, or beds of gravel as foundations, if they have the proper thickness.

DISTURBANCE CHANGES CHARACTER OF SOILS

One of the first of the perplexing phenomena of soils found in the testing laboratory is that when a soil is disturbed by man or by nature its character is entirely changed. In its undisturbed state a soil is stable and capable of resisting well-defined stresses without undue strain, but after it has been disturbed just the opposite is true. This fact leads to two immediate conclusions: first, in order to secure a stable, reliable foundation, the natural structure of the soil or clay should not be disturbed; and second, in seeking a foundation for footings, soil that has had its natural structure disturbed in any way should be avoided.

An entirely suitable foundation soil may be ruined during excavation by allowing ground water seeping from above the foundation level to run down on it. Also, men walking on the surface churn a six or eight-inch layer into a mush that is entirely unsuitable for a foundation and will start to be compressed as soon as any weight is placed on it. When the stratum of clay desired for the foundation is reached, extreme care should be taken to keep all outside

moisture off the surface. A desirable practice is to require, immediately before the concrete is poured on the soil, that the top two inches which have been disturbed by the drying-out effect of the air be peeled off to a level, firm, moist stratum.

One of the greatest natural factors tending to disturb soils is the evaporation of capillary water, which is constantly rising toward the surface. Natural clays of either marine or terrace plane deposit are filled with such water and when this is driven out, no human being can restore the clay to its original structure or give it back its original ability to carry loads. At the surface of the ground, the heat from the sun's rays evaporates the capillary water as fast as it rises. This evaporation is complete down to a certain point, then continues with gradually diminishing effect until at a certain depth below the surface the natural capillary water has not been disturbed and the original amount of water is present.

How do these points bear on the selection of a foundation? When the capillary water has been forced or driven out of a clay it becomes dry and course in structure and contains visible voids and is of a crumbly nature, filled with air. It can readily be conceived that such a soil in the first place, is very easily compressed under load, and in the second place the subsequent addition of water to the soil which will readily flow into it and instead of becoming capillary water will simply break the soil down into a mud entirely unsuitable for a foundation. On the other hand, the clay which is undisturbed contains its original capillary moisture and will not receive any additional moisture and can be relied upon to remain in the condition found.

The experienced foundation engineer can, within certain limits, determine by sight and feel, and segregate the disturbed soils from the undisturbed, but there is always a transition layer where there is

Gulf Building, Houston

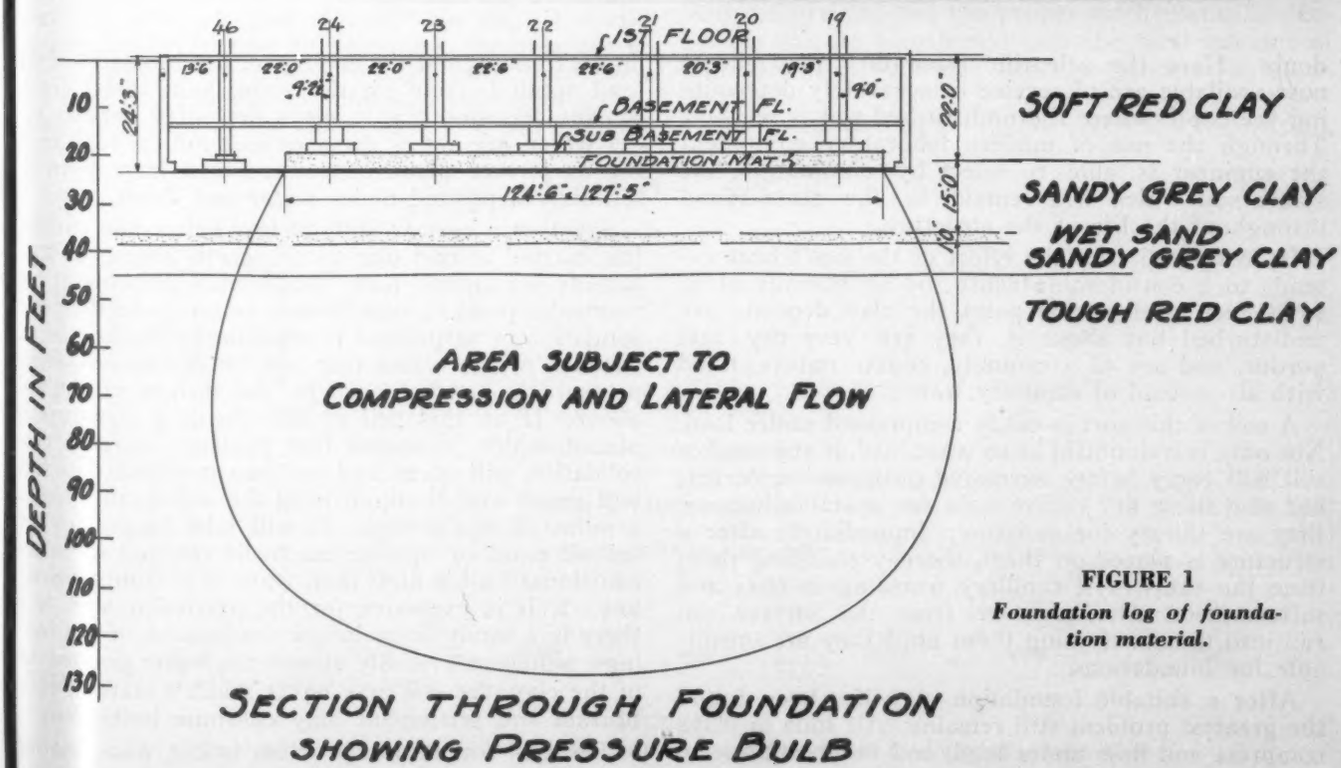

FIGURE 1
Foundation log of foundation material.

SECTION THROUGH FOUNDATION SHOWING PRESSURE BULB

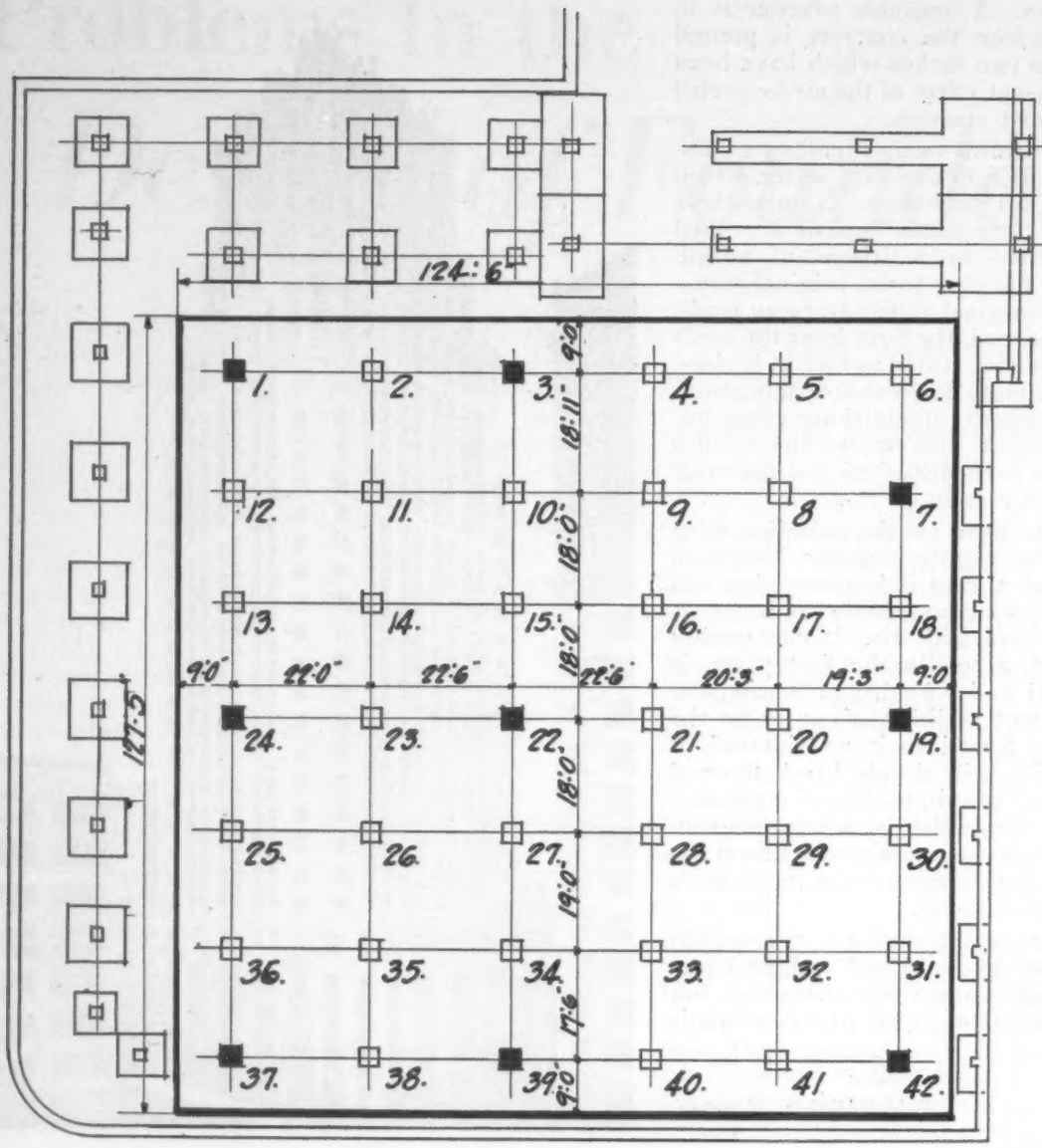

FIGURE 2

Foundation plan showing (solid) columns on which settlement readings were taken.

doubt. Here the scientific laboratory instruments now available are of service in accurately determining the depth where the undisturbed soil is reached. Through the use of modern laboratory equipment the engineer is able to select by elimination, the stable soil which will remain in the state found throughout the life of the structure.

In many vicinities the effect of the sun's heat extends to a considerable depth, on an average of 15 to 20 feet. Below this point the clay deposits are undisturbed but above it they are very dry and porous, and are of a crumbly, course nature, filled with air instead of capillary water.

A soil of this sort is easily compressed under load. Not only is it doubtful as to what load, if any, such a soil will carry before excessive compression occurs, but also these dry coarse soils are unstable because they are thirsty for moisture. Immediately after a structure is placed on them, thereby shielding them from the sun's rays, capillary water again rises and softens them. Also, moisture from the surface can run into them, softening them until they are unsuitable for foundations.

After a suitable foundation clay has been found the greatest problem still remains. All soils or clays compress and flow under load, and they continue to do so, to an extent depending on the intensity of the load applied, their plastic state, and their depth. Marine deposits, that is, clays deposited entirely under water, are not as dense or as good for load bearing as terrace plane deposits, which have been alternately deposited under water and dried.

Say that a certain soil, 20 feet below the surface, has carried a load due to the earth above, of 2300 pounds per square foot. Under this pressure it has reached a point of equilibrium as far as further consolidation or settlement is concerned; that is, the resistance of the water that can be driven out under pressure is just balanced by the weight of the soil above. If on this soil at this depth a structure is placed which increases this pressure, further consolidation will occur and settlement of the structure will result and continue until the soil again reaches a point of equilibrium. It will take longer for the second point of equilibrium to be reached when the additional load is high than when it is comparatively low. If it is excessive for the particular soil, or if there is a sandy layer below the bottom of the footings, which will readily absorb the water pressed out of the clay, the soil may never reach a state of equilibrium and settlement may continue indefinitely.

The real foundation problem is not what bearing

capacity a soil has, but how much weight can be placed on it above that which it has been previously carrying due to the surcharge load of the earth above the foundation level. In some structures the total additional load is the total weight of the structure and its live loads. In others, such as buildings with deep basements, it is this weight minus the weight of the soil excavated.

After the foundation soil has been selected and the weights to be added are known, the next point to determine is how much total settlement can be allowed for the structure in question. It has been found that there is a relation between the total settlement of a foundation and the differential settlement, that is, the difference between the maximum and the minimum settlement. A very large total settlement generally will result in an excessive differential settlement. In some types of buildings this differential settlement cannot be even ¼-inch. For instance if two adjacent footings of a residence have a differential settlement of from ¼ to ½-inch, destructive cracks will occur. In a two-story building a larger differential settlement is permissible, which means that a larger total settlement can take place. In a very tall structural steel and reinforced concrete frame office building, sometimes as much as two inches of differential settlement can be allowed, which means that four or five inches of total settlement can take place. In some types of bridges very little differential settlement can be tolerated; therefore, the total compression of the soil must be kept low.

When a load is placed on the clay, above that under which it was deposited, settlement immediately begins and continues at a rapid rate through a certain initial period and then gradually diminishes. After another period, settlement practically ceases. The additional weight that can be placed on a clay must be determined from the total settlement which the structure will stand and the length of time required for that settlement to take place.

If engineers would keep accurate time-settlement curves of each structure founded on clay, it would be comparatively easy to determine the pressure to be allowed on a similar soil in other cases. However, there are many conditions that affect the time-settlement curve besides the character of the clay; among them are the total thickness of the stratum and the presence of layers of other materials below it, such as clays of different softness, quicksand, or silt. These will make it necessary to explore to a considerable depth below the foundation proper. Laboratory methods have been perfected whereby time-settlement curves can be made from different soil samples. The samples are taken by means of an apparatus designed by S. J. Buchanan, Jun. Am. Soc. C.E. By means of this apparatus undisturbed soil samples can be taken from the clays and placed in a testing machine designed by Mr. Terzaghi. Both of these machines are discussed in the Progress Report of the Society's Special Committee on Earths and Foundations, published in the May, 1933, issue of Proceedings.

TIME-SETTLEMENT CURVES

If levels were taken on a structure built on clay over a period of several years and at regular intervals and a curve plotted to indicate the amount of settlement at each interval, it would result in the preparation of a time settlement curve (which at present, unfortunately are all too few) or a time consolidation curve, starting off steep and gradually flattening out. While such time settlement curves taken from an actual structure are unquestionably the best form of measurement by which to determine the time settlement curve for a certain clay, still it can be readily seen that quite an item of expense is involved and several years would pass before any valuable information could be accumulated.

However, there has been developed a little testing apparatus which may be used in the laboratory which will determine this time settlement curve for the engineer in a matter of a few days and which is practically as accurate as measurements over the actual structure over many years. A small disk of the foundation soil under consideration is placed into this small machine and a constant load is applied. Due to its extremely delicate measuring dials the consolidation of this one-inch sample can be determined and with this record and the proper mathematical calculations can be transferred into the total amount of consolidation of the clay bed, the thickness of which is known.

After selection of a suitable clay for a foundation,

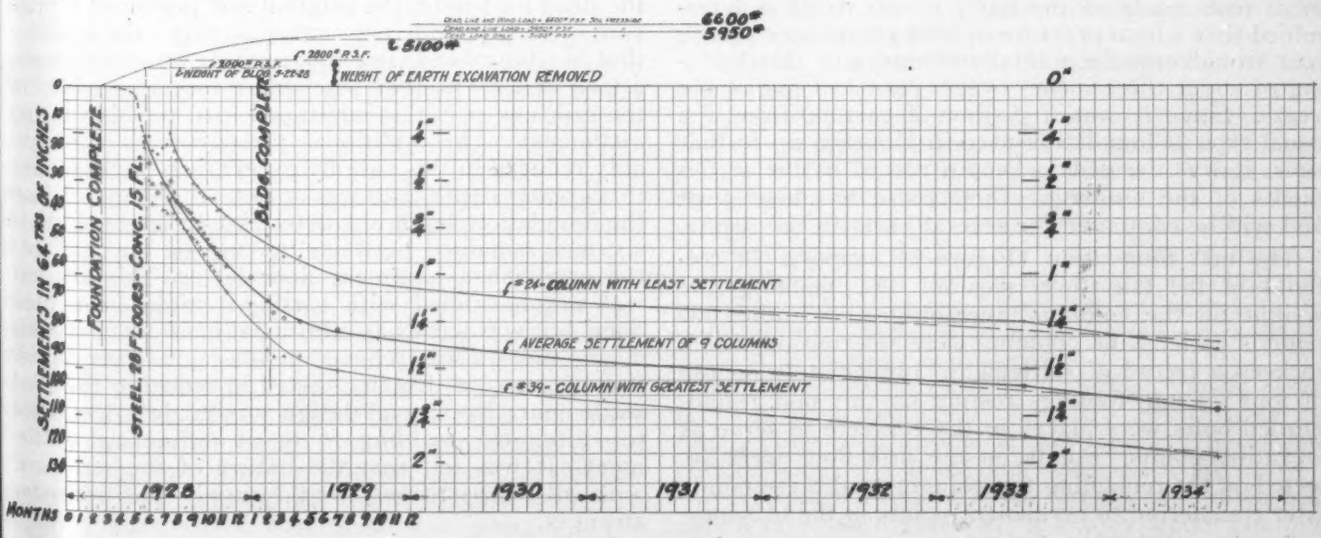

FIGURE 3

Time-settlement curves which indicate an increase in foundation load during construction

then from the time settlement curve of that clay the total settlement which can be allowed for the type of structure contemplated, must be determined and the allowable soil pressure chosen. This procedure is quite different from the old haphazard method, still employed to some extent, in guessing at the so-called soil value, at no matter what depth the foundation. All too often a foundation is designed under certain predetermined pressure for a certain depth and then after starting construction that depth is increased two or three times without decreasing the design pressure in proportion to the added overburden at the new depth.

Although the time settlement curves made in the laboratory are extremely useful to the foundation designer, those of the actual settlements of a structure are obviously the most valuable. Such curves for one of the most important buildings in Texas, the Gulf Building in Houston, may be of interest. This is an office building 35 stories high. Up to the time it was built the common method of preparing the foundations for tall buildings was to drive concrete piles into the clay subsoil on which the footings rested. Feeling that the non-compressible, impervious clay soil into which the piles would be driven, would not be in any way consolidated by the plies but that rather they would disturb it to such an extent as to soften it and possibly increase the settlement, or at best, merely transfer the pressure to the clay at the points of the piles, I advised the omission of piles. Also, this procedure would result in a saving in the cost of the building of more than $60,000.

MAT FOUNDATION

After much careful study it was decided to place a raft or mat foundation under the entire building, of such area that the total dead load would be kept at 5000 pounds per square foot and the dead and live loads and wind pressure together would not exceed 6600 pounds per square foot. It will be noted from the soil section (Figure 1) that to a depth of about 20 feet there was a rather soft red clay. The next 25 feet was a gray clay with a stratum of sand about one foot thick. This gray clay was filled with numerous small pebbles and was of medium plasticity. Below the gray clay there was a fairly tough red clay extending down more than 100 feet below the surface. From rather crude preliminary time-settlement tests made on the latter it was roughly determined that a total pressure of 6000 pounds per square foot would produce a total settlement of this building of about three inches over a period of five or six years. Since it was a distinct departure from the usual type of foundation used in Houston up to that time, it was decided to keep a record of the settlements of the building. This record has been kept and will be continued for several years in the future.

The mat foundation (Figure 2) supports 42 columns of the tall tower part of the building, the weight on the columns averaging about 2,300,000 pounds each. Nine columns were selected on which to keep a record of settlement. Immediately on top of four column footings resting on this mat round-headed bolts were placed in the concrete to serve as elevation points. Points on the first floor were selected on the remaining five columns and these points later transferred to permanent points in the masonry.

Pouring of the foundation concrete was started in the latter part of February, 1928. Settlement readings were started the latter part of May of that year, when the structural steel frame was up about 25 stories, representing a pressure on the soil of 2000 pounds per square foot. At this time the entire mat showed a small settlement. At the depth of the footings, 26 feet, the undisturbed soil pressure had been 2800 pounds per square foot.

In Figure 3 is given a curve of increasing weights of the building, designated as "load on foundation" during construction and until completion in February, 1929. At completion, the dead load on the foundation amounted to 5100 pounds per square foot. On this figure also are shown the additional pressure lines, the first representing the combined dead and live load of 5950 pounds per square foot, or a total dead, live, and wind load of 6600 pounds per square foot. The middle, time-settlement curve represents the average settlement of the nine columns. The upper curve represents that column showing the least settlement during the period, that is, column 24, and the lower curve that column showing the greatest settlement, column 39.

A smooth curve has been put through the irregular line of total settlements to make it easier to visualize the trend. It will be noted that at the beginning while weight was being added to the foundation, the settlements were pronounced and the curves rather steep, but that after completion of the building, the curve began to flatten out. Six months after completion the curves had become extremely flat. To date six years after the building was completed, the total average settlement is between 1½ and 1¾ inches, while the total differential settlement, that is, the difference between the upper and the lower curve, is about ⅝-inch.

It was anticipated that the total settlement would be between three and four inches. Of course, this determination was made from rather crude and unreliable time-settlement tests made on the soil in place. When the building was designed I did not know of the possibility of having time-settlement curves made in a laboratory; otherwise this procedure surely would have been followed. However, it would seem that the original estimate of settlement probably will not be exceeded in 10 years.

ORIGINAL SOIL PRESSURE

In this building it will be noted that, considering the dead load only, the original soil produced a pressure of 2800 pounds per square foot and the building that of 5100 pounds per square foot. In other words, a load of 2300 pounds per square foot was added to the soil, and it is this additional load that is causing settlement. The additional pressure was considerably reduced in this case by excavating the basement to a greater depth than was at first anticipated. When the foundation depth was determined a space of about six feet remained between the top of the mat and the established basement floor level. This six feet was not backfilled with earth as might have been done, but was left as an additional basement. By this means the soil was relieved to 700 pounds per square foot of pressure, which assisted in reducing the total settlement. No special design was made to endeavor to stiffen the building to resist differential settlement. It was felt that the nature of the structure, with all its partitions, would supply the necessary stiffness.

To avoid disturbing the natural structure of the foundation clay, a three-inch reinforced concrete

working slab was laid immediately after the clay was excavated to final depth. Thus the foundation soil was protected while the work of placing the steel in the mat progressed.

Another very perplexing problem encountered in the design of foundations of buildings such as for example, office buildings, research and routine laboratories, power plant buildings, large pump houses and compressor stations and the like, is the swelling tendency of certain soils.

SOILS SWELL

It is very likely that if a basement or a first floor slab is placed directly on many types of soils which have stood exposed for a number of years the original level of this slab will change. The soil swells due to moisture from several sources getting into it. This swelling occurs with a great deal of force. At one time the writer attempted to measure the intensity of the swelling tendency of some Texas soils and it was found that a certain yellow clay that commonly occurs, in which are concretions of lime or chalk and which had been disturbed and which contained Bentonite would swell with a force of over 8000 pounds per square foot. It has been noticed that the point of maximum swelling is not near the surface, but at a point three to six feet below the surface. The swelling of the soil immediately on the surface is not so forceful but it is equally as troublesome. It is known that when certain natural undisturbed clays are dried they will shrink and later moisture re-enters them and at this time they will again swell until the moisture reaches a certain state where the soil is saturated.

There are two sources of this moisture which causes the swelling. Probably the most common source is the capillary water from some reservoir forcing its way up from below. This moisture level was kept down previous to the construction of the building or other structure by evaporation due to the sun's heat, but since the erected structure provides shade and to a great extent prevents the evaporation of the capillary water, it again rises and reaches the soil immediately under the slabs and the swelling results. Another source of water is from leaky mains and pipes which will virtually always be found under buildings, homes, offices, laboratories, power plants and the like. Often the swelling of the soil breaks the pipe and the result leaks will cause more swelling.

The writer has been trying for several years to provide a method of preventing this swelling and it is felt that a partial solution has been found. When capillary water gets into the soil the only way to remove it is through air ventilation, or heat combined with air ventilation. It might be well to note that considerable success has attended the practice of placing a series of drain tile trenches under slabs which should otherwise have been expected to swell. These drain tile trenches are generally dug about four feet deep and an open tile drain placed in the bottom. The function of the tile in the bottom is to keep the reservoir or underground water which might come up to the slab at any point at least four feet below the slab. The trench then is filled, not with small gravel which would form an obstruction to the flow of air, but with very large stones about six inches in diameter and all practically the same size in order that a free flow of air can prevail in the trench. These trenches are placed at a depth of four feet and not over 12 feet apart. At intervals along their length open grates are placed in the floor or slab in order that the circulation of air may be induced. The tile drains are connected to sumps with pumps which keep the water below the four-foot level. In all instances where this practice has been employed in new structures and in all instances where the trenches were dug under old buildings where swelling had started, such swelling has ceased or, in the case of new structures, has never started.

It is useless to install any such drainage system, however, unless there is allowed a free circulation of air. It is the capillary water which causes the soil to swell, and there is nothing but air that will draw this water out of the soil and prevent it from raising. The old type of tile drain which is simply placed in a backfilled trench of earth will be of no value. This tile drain system may be considered rather expensive, and it is. However, at the first floor levels it is not quite as expensive as the suspended floor over the entire area. Unquestionably, a suspended floor is the proper method of preventing the swelling conditions at first floor levels. At basement level it is impractical to suspend the floor and the tile drain system just described can be employed to advantage.

A swelling soil condition can be expected wherever a disturbed plastic clay is encountered on which the slab is to be poured.

Vibrating engine foundations have a disturbing effect on the clay on which they rest since a vibrating foundation if too much in magnitude will alter the natural water content of the clay. The disturbing effect of this change in water content will result in a lowered capacity to carry the weight of the vibrating engine foundation.

Another disturbing effect on clay foundations is that due to heat transmitted into the ground under boilers. It can be readily seen that a disturbing effect of the heat would dry out the clay under normal conditions and make the clay more susceptible to disintegration when during flood conditions water penetrates under the boiler foundation. Foundations under boilers should have some protecting medium to insulate the foundation clays from the effects of the heat of the boilers.

To sum up our foundation problems on clays in Texas, they are:

First, to select an undisturbed soil for the foundation. Go down deep until you get it. Experience is the best guide in this, while laboratory tests will help to classify your soil.

Next, do not disturb the natural structure of the soil found.

Next, decide on the total settlement which the particular structure will stand and the rate of settlement you do not wish to exceed, and from this arrive at the pressure which will cause this settlement. This cannot be done without a thorough knowledge of the conditions of the soils for a considerable distance below the footings. Actual settlements of completed buildings will give the best time settlement curve representing a homogeneous soil for the entire depth below the footings considered.

Of all top soils which are disturbed, plastic clays are extremely unstable. They are not suitable as foundations even for the lightest loads. They swell readily when moistened and with much force.

Never place a concrete slab directly on a disturbed plastic clay soil if you want it to stay where you put it, unless the sub-soil is treated in some way to prevent swelling.

Molecular Weight *Methods*

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and
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IN MOST laboratories employing methods of finding molecular weights, the cryoscopic method is probably the most popular because of its simplicity. However, its accuracy, in some cases such as a combination of higher hydrocarbons, is questioned and the time required for its operation is excessive. Solubility, association, and other factors would be difficult, if not impossible, to measure in cases of hydrocarbons of high molecular weight. These errors render it particularly undesirable and untrustworthy in refinery control laboratories. It is therefore of value to compare the results obtained by this method with those obtained by an accurate Victor Meyer apparatus. Errors would be eliminated in vapor volume determinations by allowing for complete vaporization, the attraction and size of gas molecule. Complete vaporization is assured by use of low pressures and high temperatures. Diphenyl might be used for materials of very high molecular weight. Deviations from the gas law may be allowed for by measurements of vapor volume at different pressures and calibration to zero pressure.

The Victor Meyer apparatus used was similar to that developed by Mildred Hicks Bruun and described in the Bureau of Standards Journal of Research.[1] By combining this apparatus with the baro-buret,[2] a very accurate gas measuring device, molecular weights could be determined quite rapidly and with a high degree of accuracy. Using this as a standard of comparison, the accuracy of the cryoscopic method could be ascertained.

APPARATUS

As a vaporization chamber, the modification of the Victor Meyer gas tube by Mildred Hicks Bruun was found to be very satisfactory. As shown in Figure 1 the apparatus consists of a 35 mm Pyrex tube with constrictions at intervals fitting closely around another tube. The purpose of the constrictions is to prevent diffusion of the vapors over to the buret causing errors due to condensation. An inner tube containing a charged capillary is lowered into the guard tube. The top of the cylinder is a ground joint into which a hollow glass stopper fits, having two tungsten wires sealed into it in such a manner that a weight may be suspended from them by means of a fuse wire. When a current is sent through the fuse wire it melts, permitting the weight to fall upon the capillary. The entire tube is surrounded by a jacket in which pure aniline, water, diphenyl or a suitable heating medium is boiled. Care must be taken in the choice of a heating medium used for highly volatile liquids. The Victor Meyer tube was broken by the sudden expansion of methanol when aniline was boiled in the outer tube. Water should be used in such cases. This apparatus may be modified by use of a large constricted tube, or by using an electromagnet to hold the weight to the stopper. The type illustrated was used because of its simple heating arrangement.

In conjunction with the Victor Meyer tube, an accurate gas measuring device, the baro-buret (Figure 1) was used. As the name implies, it is a buret connected directly to a barometer. The pressure on a gas contained in the buret is measured by the height of a column of mercury in the connecting tube. A scale is mounted between the two tubes which was calibrated with a cathetometer and a correction chart drawn. Correction tables for mercury and glass expansion also were made. The baro-buret eliminates many errors which are common to the ordinary buret such as those due to inaccurate balancing of the mercury levels or balancing against the atmospheric pressure which is read separately on a barometer. It is also a decided disadvantage to measure gas volumes at only one pressure. It is, however, possible with the baro-buret to adjust the pressure to any desired value by merely raising or lowering the mercury reservoir. Thus, small volumes of gas may be accurately measured by expanding them and measuring at lower pressures. Other advantages of this type of buret as given by Booth are, simplicity of temperature control, minimizing the number of rubber connections and subsequent sources of error, and elimination of a compensator.

To determine freezing point lowering, an ordinary Beckmann type of cryoscopic apparatus was used. Ice and salt were used as the freezing agent and benzene as the solvent. The benzene was purified by crystallization and fractional distillation. Of course, benzene cannot be used as a solvent in every case but was found to be satisfactory in the cases of the liquids investigated.

PROCEDURE

A weighted capillary of the liquid to be investigated is put in the bottom of the inner tube. The weight is fixed on a fuse wire. After closing the system and pumping out the enclosed air to the desired pressure, the mercury levels are watched closely after equilibrium is reached for any possible leaks. Incidentally, the system must be thoroughly evacuated and flushed after each determination to extract any vapors which might pass over to the buret. Careful temperature control must be maintained. A current then is passed through the fuse wire, melting it and dropping the weight on the capillary. The liquid is immediately vaporized, forcing air over into the buret. A few minutes are required for the sys-

tem to reach equilibrium. The changes in pressure and volume are recorded. Because of the difficulties involved in adjusting the pressure to the same value as before evolution of the gas it was found advisable to measure the increase in volume at an unadjusted pressure. As there was a change in pressure, it was then impossible to use the fundamental gas law $PV = nRT$. The closed volume of the tube must be considered.

If we take

T_1 = Temperature of buret
T_2 = Temperature of Victor Meyer tube
P_1 = Pressure before evolution
P_2 = Pressure after evolution
V_1 = Volume of air in buret before evolution
V_1^1 = Volume of air in buret after evolution
V_2 = Volume of Victor Meyer tube
R = Gas constant
w = Weight of sample
M = Molecular weight

The number of mols of gas (air in the buret before evolution of the vapor) $n_1 = \frac{P_1 V_1}{RT_1}$

In the Victor Meyer tube $n_2 = \frac{P_1 V_2}{RT_2}$

The total number of mols $n_0 = n_1 + n_2 = \frac{P_1 V_1}{RT_1} + \frac{P_1 V_2}{RT_2}$

After evolution

(Buret) $n_1^1 = \frac{P_2 V_1^1}{RT_1}$

(Victor Meyer) $n_2^1 = \frac{P_2 V_2}{RT_2}$

Total number of mols $n_0^1 = \frac{P_2 V_1^1}{RT_1} + \frac{P_2 V_2}{RT_2}$

The change in mols of gas

$$n = n_0^1 - n_0 = \left(\frac{P_2 V_1^1}{RT_1} + \frac{P_2 V_2}{RT_2}\right) - \left(\frac{P_1 V_1}{RT_1} + \frac{P_1 V_2}{RT_2}\right)$$

As $n = \frac{w}{M}$ or $M = \frac{w}{n}$

Then $$M = \frac{w}{\left(\frac{P_2 V_1^1}{RT_1} + \frac{P_2 V_2}{RT_2}\right) - \left(\frac{P_1 V_1}{RT_1} + \frac{P_1 V_2}{RT_2}\right)}$$

Simplifying—

$$M = \frac{w}{\frac{P_2 V_1 - P_1 V_2}{RT_2} + \frac{P_2 V_1^1 - P_1 V_1}{RT_1}}$$

$$M = \frac{w}{\frac{V_2 \Delta P}{RT_2} + \frac{\Delta PV}{RT_1}}$$

Since V_2, R, T_1, and T_2 are constant

$$M = \frac{w}{K_1 \Delta P + K_2 \Delta PV}$$

where

$$K_1 = \frac{V_2}{RT_2}$$

and

$$K_2 = \frac{1}{RT_1}$$

With the equation so simplified it is only necessary to note the changes in pressure and volume. The temperatures of the Victor Meyer tube and the buret case are maintained constant. It is necessary, of course, to know the volume V_2 of the Victor Meyer tube. This is obtained by changing the pressure on the gas in the apparatus, observing the change in volume, and applying the relation

$$P_1 (V_2 + V_1) = P_2 (V_2 + V_1^1).$$

To facilitate calculations a nomograph (Figure 2) was constructed from which M could be read directly by substituting on it w, ΔP, and ΔPV. The nomograph was made of large enough dimensions that accurate measurements were possible. Details of the nomograph which is according to the equation of form

$$f_1(u) + f_2(V) = \frac{f_3(w)}{f_4(q)}$$

may be found in Lipka, Graphical and Mechanical computation.[3] The accuracy of the graph was found to be from 0.1 to 0.2 percent.

In order to obtain molecular weights of maximum accuracy, several determinations were made at different pressures and the molecular weight extrapolated byographically to zero pressure. This omits errors, due to attraction and volume of molecules, caused at comparatively high pressures and a high

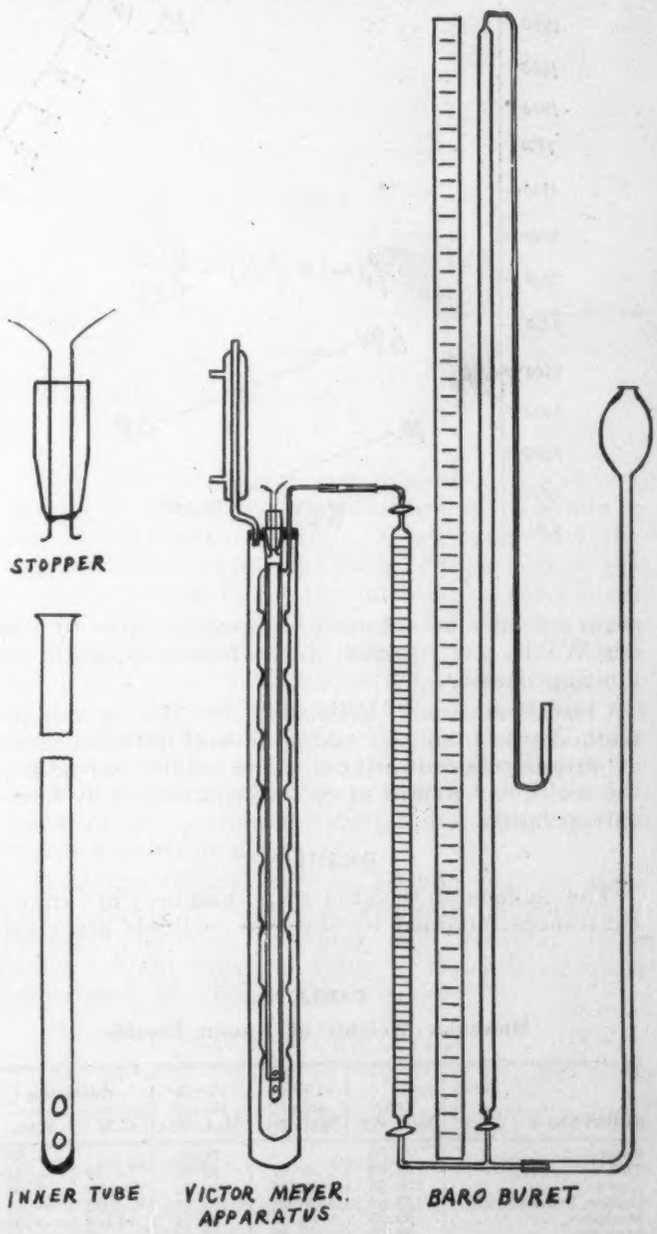

FIGURE 1
The Apparatus

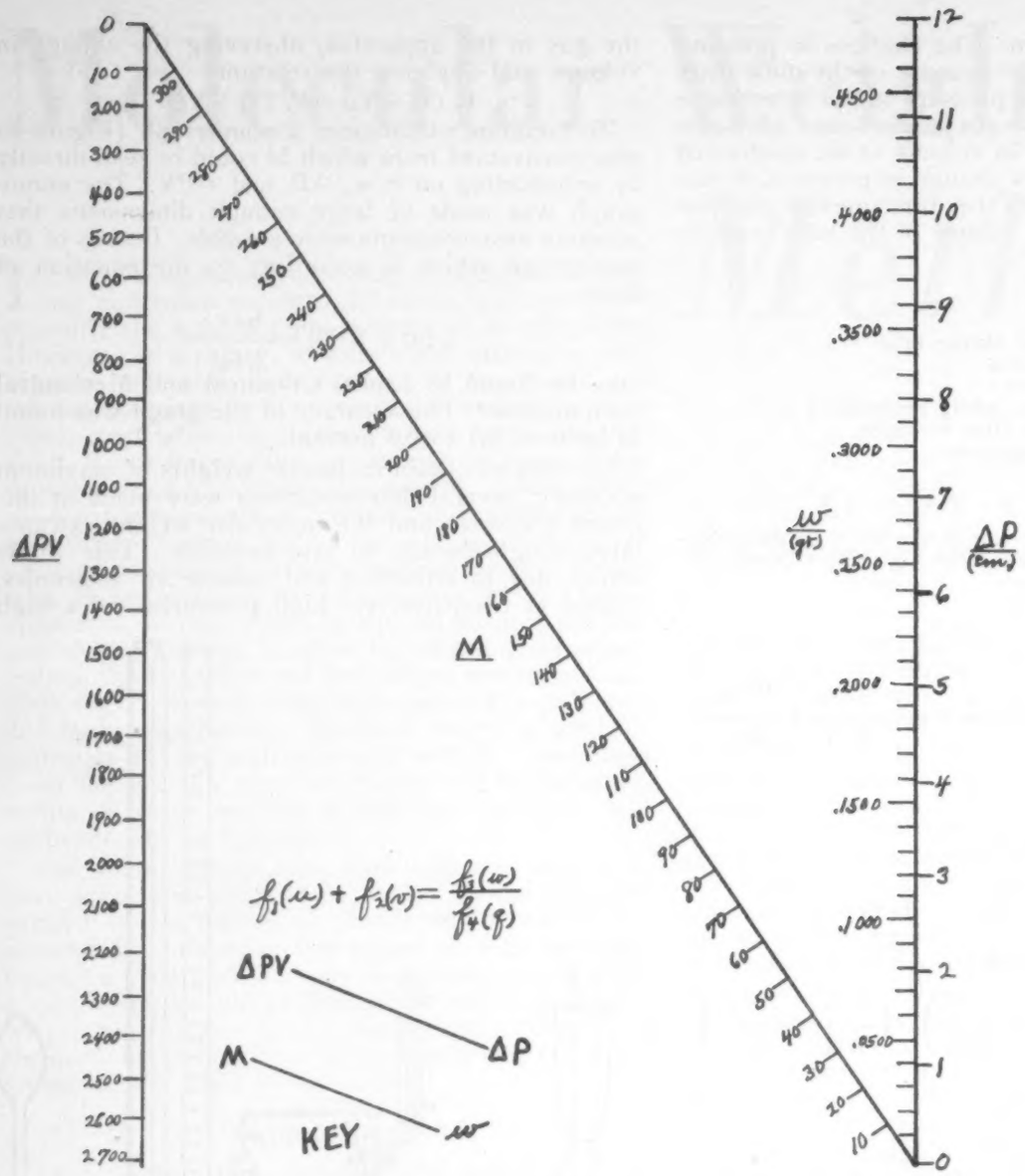

FIGURE 2
The Nomograph

accuracy may be obtained without recourse to Van der Waal's gas equation or Berthelots equation for limiting density.

Closest accuracy obtainable by the cryoscopic method was found by taking several determinations at various concentrations of the solute and finding the molecular weight at zero concentration by linear extrapolation.

RESULTS

The molecular weights of a number of known substances obtained by the two methods are given in Table I along with the true molecular weights and the deviations.

Molecular weights of 10 degree range straight run gasoline fractions between 300° and 400° F. are given in Table II showing the differences between the two methods.

A graph showing the progression of the molecular weights through the different fractions is given by Figure 3, demonstrating the variations between the two methods.

TABLE I
Molecular Weights of Known Liquids

SUBSTANCE	True Mol. Wt.	Cryoscopic Mol. Wt.	Victor Meyer Mol. Wt.	Deviation C.M.	Deviation V.M.
Benzene	78.05	.....	78.08	....	+.03
Toluene	92.06	91.87	92.02	—.19	—.04
Xylene	106.08	106.38	106.12	+.30	+.04
Carbon Tetrachloride	153.83	153.48	153.71	—.35	—.12
Methanol	32.03	32.23	32.04	+.20	+.01
Acetone	58.05	57.88	58.02	—.17	—.03
Ethanol	46.05	46.39	46.00	+.34	—.05

TABLE II
Molecular Weights of Gasoline Fractions

FRACTION	Cryoscopic Mol. Wt.	Victor Meyer Mol. Wt.	Difference Between The Two Methods
300—10° F.	117.20	119.11	1.91
310—20	121.30	123.04	1.74
320—30	125.70	127.14	1.44
330—40	130.08	131.18	1.10
340—50	134.74	135.06	.32
350—60	137.46	139.01	1.55
360—70	140.68	143.09	2.41
370—80	143.29	147.18	3.89
380—90	146.84	151.07	4.23
390—400	154.77	156.77	1.40

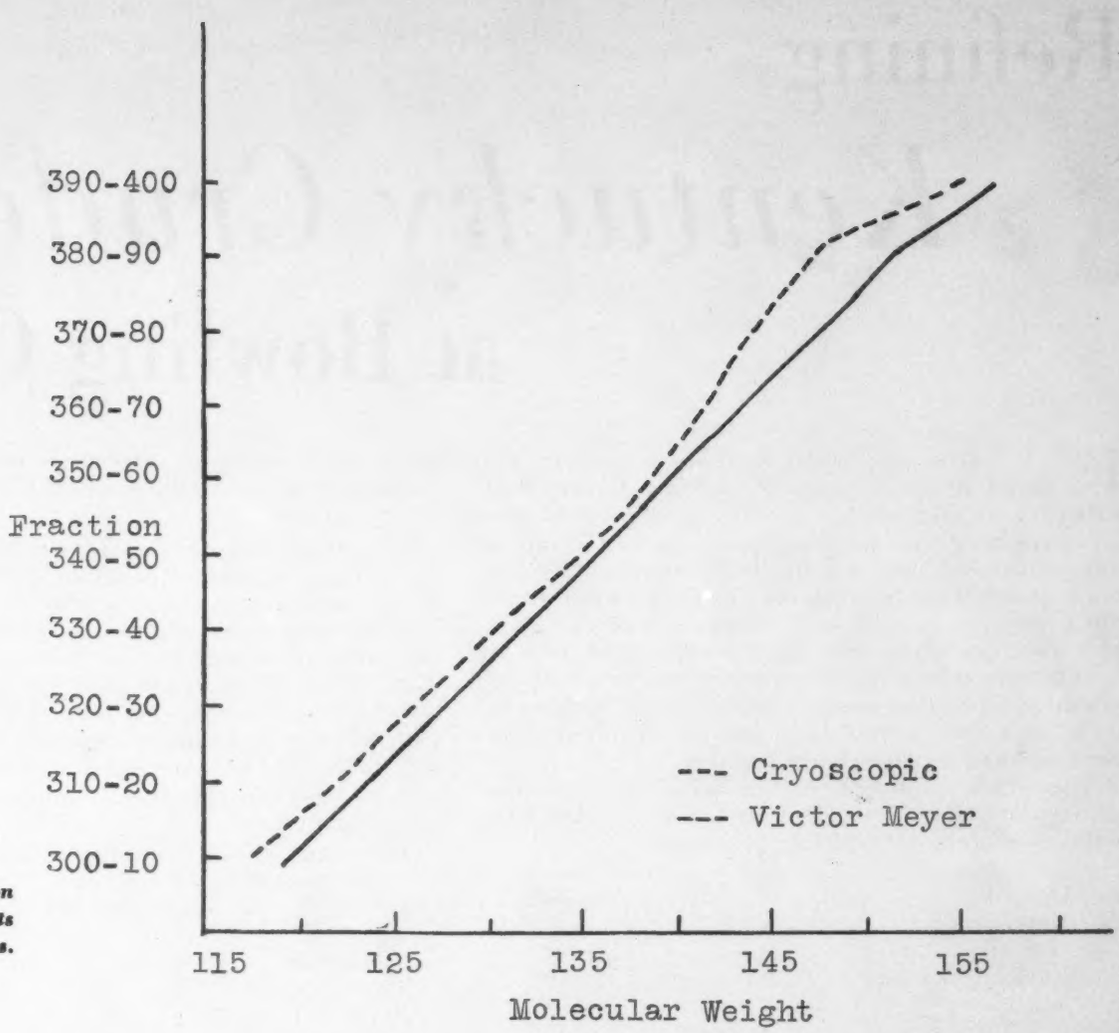

FIGURE 3
Graphic comparison of molecular weights of gasoline fractions.

CONCLUSIONS

The accuracy demonstrated by the Victor Meyer method in the case of pure substances showed the plausibility of using it as a criterion of comparison. True vapor density values were ascertained and it is quite safe to consider them as very accurate in the cases of unknown substances.

As may be seen in Table I the accuracy of the cryoscopic values vary quite widely from the true values while the Victor Meyer results vary but little. It is difficult to obtain closer results by the cryoscopic method as the constant for freezing point lowering of benzene is variable. There is, however, by the Victor Meyer method little chance for error outside of defects in experimental technique.

Upon observing the molecular weights of the gasoline fractions in Table II, even wider deviations are noted. Large irregularities occur in the cryoscopic determinations. The Victor Meyer results are quite constant however. It is very probable that the molecular weights of the fractions do not rise with regular increments, so a uniform rise in the molecular weight determinations is not expected.

Although the cryoscopic results show a rough approximation to the true weights, it is clearly seen in Figure 3 that there is a definite lack of correlation between the two methods.

This means of determining vapor densities at various pressures suggests possibilities of ascertaining gas constants and fugacity. Of late much attention has been focused upon the value of fugacities of gasoline fractions to facilitate control of pressure distillations. The gas constants may be obtained easily by observing actual conditions of a gas and substituting in Van der Waal's equation. From these constants it is possible to calculate the fugacity[4] at any temperature and pressure. Another method utilizing this procedure is the graphical method[5] in which the isotherm of a perfect gas is plotted with the isotherm of the gas under question and observing the variance between the two.

Many possibilities may be seen in such an apparatus capable of producing accurate measurements on vapor volumes, pressures, and densities, and it will no doubt prove of value in many laboratories where such measurements are desired.

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[3]Lipka. *Graphical and Mechanical Computation.* John Wiley and Sons, 1918.

[4]Lewis and Randall, *Thermodynamics.* McGraw Hill Book Company, 1923, pp 195-96.

[5]Lewis and Randall, *Thermodynamics.* McGraw Hill Book Company, 1923, pp 192-94.

Refining *Kentucky Crude* at Bowling Green

FOUR years ago, when markets for crude produced in the vicinity of Bowling Green, Kentucky, were curtailed, and the producers in that area had no outlet for their production, a group of independent oil men nearby decide to build a skimming plant. This became the Bowling Green Refining Company. A tract of land was secured at Memphis Junction, about two miles southwest of Bowling Green upon which the plant was constructed. It was placed in operation in the summer of 1930, designed to process 1500 barrels daily, but the throughput has been boosted to 2000 barrels a day.

The crude produced in this area has an average gravity of about 34° A. P. I. and is of a mixed base, with a laboratory break up as follows:

	Percent
Gasoline	30
Kerosene	7
Gas oil	15
Fuel oil and loss	48
Total	100

The oil is called a normal sweet product, but contains a small amount of sulphur and sulphur compounds, enough to call for sweetening of the gasoline and kerosene fractions.

The crude handled has an average temperature of 80°F. It is picked up by a steam driven duplex pump, and discharged through a vapor to crude exchanger placed on the vapor line just before the gasoline vapors enter the submerged condenser pipe coils. About 160°F. is the temperature of the crude as it passes through the exchanger, and it immediately is passed through three other units, which are used as residuum to charge heaters. These are suspended in a vertical position beside the fractionating column.

Bowling Green Refining Company's Bowling Green, Kentucky, refinery, consisting of tube still and fractionating equipment.

The temperature of the oil as it leaves the bottoms to charge exchangers is about 320°F., after which it is passed through a bs&w and salt water separator. The charging line continues on from the separator to the tube still which has 48 tubes in the convection bank and 16 tubes in the roof. These tubes are three inch O.D. and are 20 feet long. The tubes are fitted with headers to facilitate cleaning when it is necessary to turbine because of coke deposition. The pipe still is fired through special burners made for fuel oil consumption.

The plant yields from the column, a tower four feet in diameter by 58 feet high, containing 22 trays and bubble caps, are as follows:

	Percent
Gasoline	29.64
Kerosene	8.33
Gas Oil	16.71
Fuel Oil	44.19
Gas and Loss	1.33
Total	100.00

Gasoline is removed as an overhead stream, while kerosene and gas oil are removed from draw off pans which have connecting lines leading to side strippers placed on a platform level with the foundation of the condenser box. Stripping is controlled with the auxiliary towers, which have four trays each, so that specified grades of these products may be manufactured more easily.

The gasoline has an initial boiling point of from 98 to 100°F., and an end point of 400°F. The 50 percent over point is maintained on an average of 240°F. and is comparatively sweet. The gas oil is cut to Diesel specifications and has an ash content of less than 0.1 percent. Kerosene is cut to 42-44° A. P. I., and has an initial boiling point of 360°F. and an end point of 480 to 490°F. The fuel oil has a gravity of from 21 to 23° A. P. I., according to market conditions and buyers specifications. It has an ash content of less than 0.7 percent. The ash content of the fuel oil is controlled by removing the bs&w and salt water before the oil enters the pipe still. This fuel is sold almost exclusively to glass manufacturers in the north and eastern states.

The plant is managed by the company personnel but is directed by the association of oil producers who conceived the idea of erecting the plant as an outlet for crude produced from that section of the state.

United Gas Public Service Company, Myrtis (Vivian) Louisiana, gasoline plant which has recently been doubled in capacity through addition of an entire new installation adjacent to the company's original plant.

Isopentane

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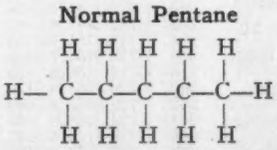
ISOPENTANE and pentane are predominant constituents of natural gasoline. As such, their physical and thermodynamic properties should be of interest to the industry and in particular to those engaged in design of equipment and plant operation. In a previous article [REFINER, May, 1935, P. 232] the writer discussed some of the properties of methane and ethane and gave a set of tables covering the physical and thermodynamic properties of their saturated liquids and vapors. The logical sequence of presentation would be propane, isobutane and butane, but as there are limited tables for these substances already available, it was decided to present herewith the next higher member, namely, isopentane. It will be noted that this table covers the temperature range for this hydrocarbon from its boiling point at atmospheric pressure to the critical point for intervals of 2°F. This table should replace most of the tedious approximation methods now used for calculating volumes, pressures, densities, heat content and entropy of this compound.

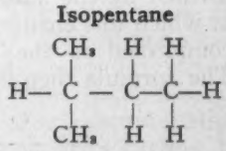
The boiling point of isopentane, 82.3°F., lies between that of normal butane and normal pentane. It is therefore a highly valuable constituent of motor fuel as its properties are such as to give ease of starting without much loss by vaporization. This should be of particular interest to those engaged in the manufacture of aviation gasoline from natural gas as a sharp cut between butane and isopentane would give a stable gasoline of high volatility.

Isopentane is of the same molecular weight and has the same empirical formula, C_5H_{12}, as normal pentane. The differences in chemical and physical characteristics are due to the manner in which the 5 carbon atoms and 12 hydrogen atoms are combined. The structural formulae are:

Normal Pentane



Isopentane



In the manufacture of amyl alcohols, $C_5H_{11}OH$, it is therefore advisable to separate the pentanes before processing in order to obtain a pure product. The pentanes may be separated from each other by means of fractional distillation.

THERMODYNAMIC PROPERTIES

Entropy. The values under the heading "s" for en-

tropy in the table apply to the liquid. Those under "S" apply to the vapor. This is specifically called to the attention of the reader as there has been some question as to values given in previous tables for methane and ethane. In this table for isopentane as in the tables for methane and ethane the values are given for intervals of 2°F. In other words

$$T_2 - T_1 = 2°F.$$

The use of an average temperature in calculating the entropy of the liquid therefore introduces a negligible variation from the perferable differential form

$$S_2 - S_1 = \int_1^2 \frac{dQ}{T}$$

When substances is heated without change of state, the temperature rises, varying with Q. For small intervals such as 2°F. the use of an average value for T is permissible for engineering calculations. For the information of those desiring to make their own entropy calculations, it may be stated that the heat content values given in the tables are based upon experimental results. The entropy change may therefore be calculated from the equation

$$S_2 - S_1 = W\ C \log_e \left[\frac{T_2}{T_1}\right]$$

where $$C = \frac{dQ}{dT},$$

a justifiable assumption for a 2°F. change of temperature at substantially constant volume. For calculating mean specific heat over appreciable temperature ranges, the a, b, and c factors may be determined by the solution of simultaneous equations of the form

$$C = a + b\ T + C\ T^2$$

When a pure substance changes state, as from a liquid to a vapor, at constant pressure there is no change of temperature. The number of Btu required to cause this change of state divided by the absolute temperature at which this change of state was accomplished is the entropy change. The formula then is simply

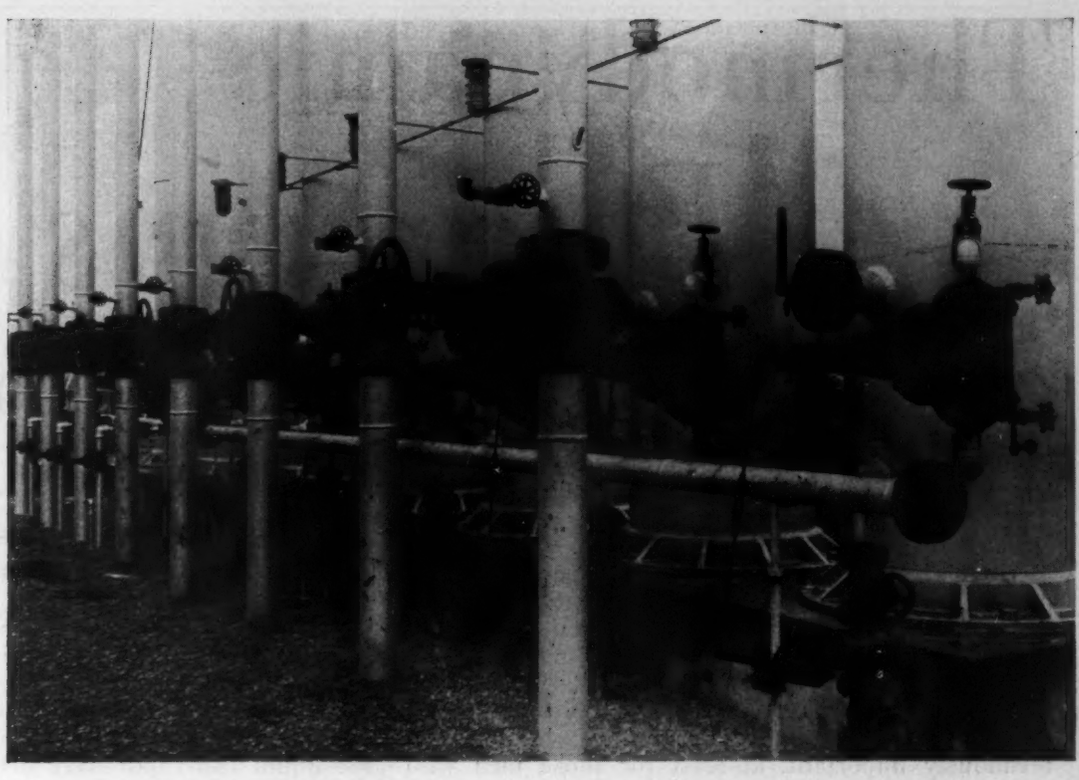
$$\frac{Q}{T\ abs.}$$

HEAT CONTENT

In the table the heat of the liquid at its normal boiling point is taken arbitrarily as zero. This is given under the sub-heading "h". To find the specific heat between any inter-

Physical and Thermodynamic Properties of Isopentane

Temp.		Pressure Lb./In.		Volume Ft./Lb.		Density Lb./Ft.		HEAT CONTENT Above 82° F. Btu/lb.					Entropy	
				Liquid	Vapor	Liquid	Vapor	Liquid	Latent	Vapor	Int.	Ext.	Liquid	Vapor
°F.	°Ab.	Gauge	Abs.	v	V_2	d	D	h	L	H	u	e	s	S
82.3	542	.0	14.70	.02608	5.3191	38.85	.189	.0	150.0	150.0	135.6	14.4	0.0	.277
84	544	.3	15.00	.02616	5.0505	38.18	.198	1.1	149.1	150.2	134.8	14.3	.003	.277
86	546	.7	15.4	.02624	4.8544	38.01	.206	2.3	148.2	150.5	134.0	14.2	.005	.277
88	548	1.5	16.2	.02632	4.6729	37.94	.214	3.4	147.4	150.8	133.3	14.1	.008	.277
90	550	2.2	16.9	.02641	4.4843	37.87	.223	5.7	146.6	152.3	132.6	14.0	.010	.277
92	552	3.0	17.7	.02645	4.3290	37.80	.231	6.8	145.8	152.6	132.1	13.7	.012	.277
94	554	3.7	18.4	.02649	4.1667	37.73	.240	8.0	145.0	153.0	131.7	13.3	.014	.276
96	556	4.5	19.2	.02653	4.0323	37.66	.248	9.1	144.2	153.3	131.2	13.0	.016	.276
98	558	5.2	19.9	.02657	3.9063	37.59	.256	10.3	143.5	153.8	130.8	12.7	.018	.276
100	560	6.0	20.7	.02661	3.7736	37.51	.265	11.4	142.6	154.0	130.3	12.3	.020	.275
102	562	6.7	21.4	.02666	3.6630	37.44	.273	12.6	142.6	155.2	129.8	12.8	.022	.276
104	564	7.4	22.1	.02671	3.5587	37.37	.281	13.8	142.5	156.3	129.3	13.2	.024	.277
106	566	8.2	22.9	.02676	3.4247	37.30	.292	14.9	142.4	157.3	128.8	13.6	.026	.278
108	568	9.1	23.8	.02681	3.3113	37.23	.302	16.1	142.4	158.5	128.3	14.1	.028	.279
110	570	9.9	24.6	.02686	3.2051	37.15	.312	17.3	142.3	159.6	127.8	14.5	.030	.280
112	572	10.7	25.4	.02692	3.1056	37.08	.322	18.5	141.6	160.1	127.4	14.2	.032	.280
114	574	11.6	26.3	.02698	3.0030	37.00	.333	19.7	140.8	160.5	127.0	13.8	.034	.279
116	576	12.4	27.1	.02704	2.9155	36.93	.343	20.8	140.2	161.0	126.7	13.5	.036	.279
118	578	13.2	27.9	.02710	2.8321	36.85	.353	22.0	139.5	161.5	126.3	13.2	.038	.279
120	580	14.1	28.8	.02716	2.7548	36.78	.363	23.2	138.7	161.9	125.9	12.8	.040	.280
122	582	14.9	29.6	.02722	2.6738	36.70	.374	24.4	138.5	162.9	125.4	13.1	.042	.281
124	584	16.0	30.7	.02728	2.5840	36.62	.387	25.6	138.4	164.0	124.9	13.5	.044	.281
126	586	17.1	31.8	.02734	2.5063	36.54	.399	26.8	138.3	165.1	124.4	13.9	.046	.282
128	588	18.2	32.9	.02740	2.4272	36.47	.412	28.0	138.1	166.1	123.9	14.2	.048	.283
130	590	19.3	34.0	.02748	2.3529	36.39	.425	29.3	138.0	167.0	123.4	14.6	.050	.283
132	592	20.3	35.0	.02754	2.2883	36.31	.437	30.5	137.6	168.1	123.0	14.6	.052	.284
134	594	21.4	36.1	.02760	2.2272	36.23	.449	31.7	137.2	168.9	122.6	14.6	.054	.284
136	596	22.5	37.2	.02766	2.1645	36.15	.462	32.9	136.8	169.7	122.1	14.7	.056	.285
138	598	23.5	38.2	.02772	2.1053	36.17	.475	34.2	136.4	170.6	121.7	14.7	.057	.285
140	600	24.6	39.3	.02778	2.0534	35.99	.487	25.3	136.0	171.3	121.3	14.7	.059	.285
142	602	25.8	40.5	.02784	1.9881	35.91	.503	36.6	135.1	171.7	120.4	14.7	.061	.285
144	604	27.1	41.8	.02790	1.9268	35.84	.519	37.8	134.2	172.0	119.5	14.7	.063	.285
146	606	28.3	43.0	.02796	1.8692	35.76	.535	39.1	133.4	172.5	118.6	14.8	.065	.284
148	608	29.6	44.3	.02802	1.8144	35.68	.551	40.3	132.5	172.8	117.7	14.8	.067	.284
150	610	30.8	45.5	.02809	1.7637	35.60	.567	41.6	131.6	173.2	116.8	14.8	.068	.284
152	612	32.0	46.7	.02815	1.7182	35.52	.582	42.8	131.3	174.1	116.5	14.8	.070	.284
154	614	33.2	47.9	.02821	1.6722	35.45	.598	44.1	130.8	174.9	116.1	14.7	.072	.285
156	616	34.5	49.2	.02827	1.6287	35.37	.614	45.4	130.4	175.8	115.7	14.7	.074	.285
158	618	36.7	51.4	.02833	1.5873	35.29	.630	46.7	130.0	176.7	115.4	14.6	.076	.286
160	620	37.2	51.9	.02839	1.5408	35.21	.649	47.9	129.5	177.4	115.0	14.5	.077	.286
162	622	37.6	52.3	.02846	1.4970	35.13	.668	49.2	128.9	178.1	114.7	14.2	.079	.286
164	624	38.1	52.8	.02853	1.4535	35.05	.688	50.5	128.5	179.0	114.5	14.0	.081	.286
166	626	38.6	53.3	.02860	1.4144	34.97	.707	51.8	127.9	179.7	114.2	13.7	.083	.286
168	628	39.0	53.7	.02867	1.3755	35.89	.727	53.1	127.4	180.5	114.0	13.4	.085	.286
170	630	39.3	54.0	.02873	1.3405	34.81	.746	54.4	126.8	181.2	113.7	13.1	.086	.286
172	632	40.0	54.7	.02880	1.3055	34.73	.766	55.7	126.4	182.1	113.3	13.1	.088	.287
174	634	40.4	55.1	.02887	1.2723	34.65	.786	57.0	125.9	182.9	112.8	13.1	.090	.288
176	636	40.9	55.6	.02894	1.2422	34.57	.805	58.3	125.4	183.7	112.3	13.1	.092	.289
178	638	43.9	58.6	.02901	1.2077	34.48	.828	59.6	124.9	184.5	111.8	13.1	.094	.289
180	640	46.9	61.6	.02908	1.1751	34.39	.851	61.0	124.4	185.4	111.3	13.1	.095	.290
182	642	50.0	64.7	.02915	1.1455	34.31	.873	62.3	124.2	186.5	110.8	13.4	.097	.291
184	644	53.0	67.7	.02922	1.1161	34.26	.896	63.6	124.0	187.6	110.3	13.7	.099	.292
186	646	56.0	70.7	.02929	1.0881	34.13	.919	64.9	123.8	188.7	109.8	14.0	.101	.292
188	648	59.0	73.7	.02936	1.0753	34.04	.930	66.3	123.6	189.9	109.4	14.2	.103	.293
190	650	62.0	76.7	.02945	1.0493	33.96	.953	67.6	123.4	191.0	108.9	14.5	.104	.294
192	652	65.1	79.8	.02958	1.0132	33.87	.987	69.0	122.9	191.9	108.4	14.6	.106	.295
194	654	68.1	82.8	.02971	.9901	33.78	1.01	70.3	122.4	192.1	107.8	14.6	.108	.295
196	656	70.3	85.0	.02984	.9615	33.62	1.04	71.7	121.9	193.6	107.3	14.7	.110	.296
198	658	72.4	87.1	.02997	.9434	33.46	1.06	73.0	121.4	194.4	106.7	14.7	.112	.296
200	660	74.7	89.4	.03010	.9174	33.30	1.09	74.4	120.8	195.2	106.1	14.7	.113	.296
202	662	76.8	91.5	.03223	.8929	33.15	1.12	75.7	120.2	195.9	105.5	14.7	.115	.296
204	664	79.0	93.7	.03036	.8696	32.99	1.15	77.1	119.5	196.6	104.9	14.6	.116	.296
206	666	81.2	95.9	.03049	.8475	32.83	1.18	78.5	118.9	197.4	104.3	14.6	.118	.297
208	668	83.4	98.1	.03062	.8264	32.67	1.21	79.9	118.1	198.0	103.6	14.5	.119	.297
210	670	85.6	100.3	.03076	.8130	32.51	1.23	81.2	117.5	198.7	103.0	14.5	.121	.297
212	672	87.8	102.5	.03080	.7937	32.35	1.26	82.6	117.0	199.6	102.5	14.5	.123	.297
214	674	90.6	105.3	.03084	.7692	32.32	1.30	84.0	116.5	200.5	102.0	14.5	.125	.298
216	676	93.4	108.1	.03088	.7519	32.29	1.33	85.4	115.9	201.3	101.5	14.4	.127	.298
218	678	96.2	110.9	.03092	.7353	32.26	1.36	86.8	115.3	202.1	100.9	14.4	.129	.299
220	680	98.9	113.6	.03096	.7143	32.24	1.40	88.2	114.8	203.0	100.4	14.4	.130	.299
222	682	101.7	116.4	.03100	.6993	32.20	1.43	89.6	114.3	203.9	99.9	14.4	.132	.299
224	684	104.7	119.4	.03104	.6849	32.16	1.46	91.0	113.8	204.8	99.4	14.4	.133	.300
226	686	107.2	121.9	.03108	.6667	32.13	1.50	92.4	113.2	205.6	98.9	14.3	.135	.300
228	688	109.9	124.6	.03112	.6536	32.10	1.53	93.8	112.7	206.5	98.4	14.3	.137	.301
230	690	112.7	127.4	.03118	.6369	32.07	1.57	95.1	112.2	207.3	97.9	14.3	.138	.301
232	692	115.8	130.5	.03128	.6211	31.97	1.61	96.5	111.4	207.9	97.2	14.2	.140	.301
234	694	118.9	133.6	.03138	.6061	31.87	1.65	97.9	110.7	208.6	96.5	14.2	.142	.301
236	696	122.0	136.7	.03148	.5882	31.71	1.70	99.2	109.8	209.0	95.8	14.1	.143	.301
238	698	125.1	139.8	.03158	.5747	31.66	1.74	100.7	109.2	209.0	95.1	14.1	.145	.301
240	700	128.2	142.9	.03168	.5618	31.56	1.78	102.1	108.4	210.5	94.4	14.0	.146	.301
242	702	131.2	145.9	.03179	.5495	31.45	1.82	103.6	107.9	211.5	93.9	14.0	.148	.301
244	704	134.3	149.0	.03190	.5376	31.35	1.86	105.0	107.3	212.3	93.4	13.9	.149	.302
246	706	137.3	152.0	.03201	.5263	31.24	1.90	106.5	106.7	213.2	92.8	13.9	.151	.302
248	708	140.4	155.1	.03212	.5155	31.14	1.94	107.9	106.1	214.0	92.3	13.8	.152	.303
250	710	144.0	158.7	.03224	.5025	31.03	1.99	109.4	105.6	215.0	91.8	13.8	.154	.303
252	712	147.6	162.3	.03236	.4926	30.91	2.04	110.7	104.9	215.6	91.1	13.8	.156	.303
254	714	151.2	165.9	.03248	.4785	30.80	2.08	112.2	104.1	216.3	90.4	13.7	.157	.303
256	716	154.7	169.4	.03260	.4673	30.68	2.14	113.7	103.3	217.0	89.7	13.6	.159	.303
258	718	158.3	173.0	.03272	.4566	30.57	2.19	115.2	102.6	217.8	89.0	13.6	.161	.303
260	720	161.8	176.5	.03284	.4464	30.46	2.24	116.6	101.8	218.4	88.3	13.5	.162	.303
262	722	165.4	180.1	.03297	.4367	30.34	2.29	118.1	101.0	219.1	87.6	13.4	.164	.303
264	724	168.9	183.6	.03310	.4274	30.23	2.34	119.6	100.3	219.9	86.9	13.4	.165	.303
266	726	172.6	187.3	.03323	.4184	30.11	2.39	121.1	99.5	220.6	86.2	13.3	.167	.304
268	728	176.8	191.5	.03336	.4032	29.99	2.48	122.6	98.8	221.4	85.5	13.3	.169	.304
270	730	181.0	195.7	.03349	.3968	29.86	2.52	124.1	98.0	222.1	84.8	13.2	.170	.304
272	732	185.1	199.8	.03364	.3876	29.74	2.58	125.6	97.1	222.7	84.0	13.1	.172	.304
274	734	189.3	204.0	.03379	.3788	29.61	2.64	127.1	96.3	223.4	83.3	13.0	.173	.304
276	736	193.5	208.2	.03394	.3704	29.48	2.70	128.7	95.5	224.7	82.5	13.0	.175	.305
278	738	197.6	212.3	.03409	.3610	29.36	2.77	130.1	94.7	224.8	81.8	12.9	.176	.305
280	740	201.7	216.4	.03424	.3534	29.23	2.83	131.7	93.8	225.5	81.0	12.8	.178	.305
282	742	205.9	220.6	.03439	.3460	29.10	2.89	133.2	93.1	226.3	80.4	12.7	.180	.305
284	744	210.1	224.8	.03454	.3390	28.97	2.95	134.7	92.4	227.1	79.8	12.6	.181	.306
286	746	213.8	228.5	.03470	.3311	28.83	3.02	136.2	91.7	227.9	79.2	12.5	.183	.306
288	748	217.4	232.1	.03486	.3236	28.70	3.09	137.8	90.9	228.7	78.5	12.4	.184	.307
290	750	221.1	235.8	.03502	.3175	28.56	3.15	139.3	90.2	229.5	77.9	12.3	.186	.307



val such as for example between 82.3°F. and 108°F.

$$h_2 - h_1 = 16.1 - 0 = 16.1 \text{ Btu}$$
$$T_2 - T_1 = 568 - 542.3 = 25.7$$
$$\frac{16.1}{25.7} = 0.623$$

or similarly for any other temperature range.

It will be further noted that L, the latent heat of vaporization is equal to u + e. This recognizes the phenomena that the heat used in vaporization is taken up in two ways, namely (1), to overcome the cohesive effect of the molecules in the liquid and (2) to cause the expansion in volume from a liquid to a vapor. The internal heat = u and the external heat = e. Such values are of importance to thermo-chemical calculation.

The total heat content H = u + e + h. In other words the total heat of a vapor includes the Btu content of the liquid, plus the heat required for vaporization which = u + e. The heat content of the liquid is not an absolute value as it is taken from an arbitrarily fixed temperature, in this case 82.3°F. The total heat content rises to a maximum of 240.0 at 340°F. = 800° Abs and then gradually decreases to 205.9 at the critical point. In other words the heat content of the saturated vapor is 34.1 B.t.u. per pound greater at 340° F. than it is at 370°F.

In most cases where heat transfer is involved as in fractionation or heating, the temperature is relied upon as an indication of the heat content. The difference in heat content may be as high as 150 B.t.u. per pounds depending upon whether or not the isopentane is liquid or vapor. For example, suppose a mixture of hydrocarbon is preheated before passing into a fractionating column. The temperature might indicate 92° F. at three pounds gauge. If the material was isopentane the difference in heat content per pound between the liquid and vapor would be 146.6 B.t.u.

Physical and Thermodynamic Properties of Isopentane—(Continued)

Temp.		Pressure Lb./In.		Volume Ft./Lb.		Density Lb./Ft.		HEAT CONTENT Above 82° F. Btu/lb.					Entropy	
				Liquid	Vapor	Liquid	Vapor	Liquid	Latent	Vapor	Int.	Ext.	Liquid	Vapor
°F.	°Ab.	Gauge	Abs.	v	V_2	d	D	h	L	H	u	e	s	S
292	752	224.8	239.5	.03521	.3115	28.42	3.21	140.9	89.4	230.3	77.2	12.2	.188	.307
294	754	228.4	243.1	.03540	.3049	28.28	3.28	142.4	88.6	231.6	76.5	12.1	.189	.307
296	756	232.1	246.8	.03559	.2994	28.15	3.34	144.0	87.8	231.8	75.8	11.9	.191	.308
298	758	235.8	250.5	.03578	.2933	28.01	3.41	145.5	86.9	232.4	75.0	11.8	.192	.308
300	760	239.4	254.1	.03597	.2882	27.88	3.47	147.1	86.1	233.2	74.3	11.7	.194	.308
302	762	243.2	257.9	.03616	.2825	27.73	3.54	148.7	85.1	233.7	73.4	11.6	.195	.308
304	764	249.3	264.0	.03635	.2740	27.56	3.65	150.2	84.0	234.2	72.4	11.5	.197	.307
306	766	255.5	270.2	.03654	.2660	27.40	3.76	151.8	82.9	235.7	71.4	11.3	.198	.307
308	768	261.7	276.4	.03673	.2577	27.24	3.88	153.4	81.8	235.2	70.5	11.2	.200	.306
310	770	268.0	282.7	.03693	.2506	27.08	3.99	154.9	80.7	235.6	69.5	11.1	.201	.306
312	772	274.3	289.0	.03717	.2439	26.91	4.10	156.5	79.3	235.8	68.2	11.0	.203	.305
314	774	280.5	295.2	.03745	.2370	26.75	4.22	158.1	78.0	236.1	67.0	10.9	.205	.305
316	776	286.9	301.6	.03774	.2310	26.58	4.33	159.7	76.6	236.3	65.7	10.7	.206	.304
318	778	293.2	307.9	.03788	.2252	26.42	4.44	161.3	75.1	236.4	64.4	10.6	.207	.304
320	780	299.6	314.3	.03817	.2198	26.25	4.55	162.9	73.7	236.6	63.1	10.4	.209	.303
322	782	305.4	320.1	.03846	.2128	26.05	4.70	164.5	72.5	237.0	62.1	10.4	.210	.303
324	784	311.4	326.1	.03876	.2176	25.85	4.84	166.1	71.4	237.5	61.2	10.2	.212	.303
326	786	317.6	332.3	.03806	.2008	25.69	4.98	167.7	70.2	237.9	60.2	10.0	.213	.302
328	788	323.8	338.5	.03937	.1953	25.44	5.12	169.3	69.1	238.4	59.3	9.8	.215	.302
330	790	330.0	344.7	.03968	.1901	25.24	5.26	170.9	67.9	238.8	58.3	9.6	.216	.302
332	792	336.3	351.0	.04000	.1852	25.03	5.40	172.6	65.5	239.1	57.2	9.4	.218	.302
334	794	342.3	357.0	.04032	.1802	24.83	5.55	174.2	65.1	239.3	55.9	9.2	.220	.301
336	796	348.5	363.2	.04065	.1761	24.62	5.68	175.8	63.7	239.5	54.7	9.0	.221	.301
338	798	354.9	369.6	.04098	.1715	24.42	5.83	177.5	62.3	239.8	53.5	8.8	.222	.300
340	800	360.9	375.6	.04149	.1650	24.14	6.06	179.1	60.9	240.0	52.3	8.6	.224	.300
342	802	367.8	382.5	.04202	.1592	23.85	6.28	180.8	59.0	239.8	50.7	8.3	.226	.299
344	804	374.8	389.5	.04255	.1536	23.56	6.51	182.4	57.1	239.5	49.1	8.0	.227	.298
346	806	381.5	396.2	.04310	.1486	23.27	6.73	184.1	55.3	239.4	47.5	7.8	.228	.297
348	808	388.4	403.1	.04367	.1439	22.99	6.95	185.7	53.4	239.1	45.9	7.5	.230	.296
350	810	395.3	410.0	.04405	.1393	22.70	7.18	187.4	51.4	238.8	44.2	7.2	.231	.295
352	812	402.3	417.0	.04464	.1351	22.41	7.40	189.0	48.8	237.8	42.2	6.6	.233	.293
354	814	409.1	423.8	.04525	.1311	22.12	7.63	190.7	44.9	235.6	40.1	4.8	.234	.290
356	816	416.0	430.7	.04587	.1274	21.83	7.85	192.4	41.5	233.9	38.0	3.5	.236	.287
358	818	423.4	438.3	.04695	.1205	21.35	8.30	194.0	38.3	232.3	36.0	2.3	.238	.284
360	820	430.8	445.5	.048–8	.1145	20.85	8.73	195.7	34.9	230.6	33.9	1.0	.239	.281
362	822	438.3	453.0	.04926	.1091	20.36	9.17	197.4	28.1	225.5	27.3	.8	.241	.275
364	824	444.6	460.3	.05051	.1041	19.87	9.61	199.1	21.1	220.2	20.5	.6	.243	.268
365	825	449.5	464.2	.05102	.1018	19.61	9.82	200.8	17.6	218.4	17.1	.5	.244	.265
366	826	453.4	468.1	.05376	.0844	18.60	10.84	202.5	14.0	216.5	13.6	.4	.245	.261
368	828	461.2	475.9	.06024	.0787	16.60	12.70	204.2	7.1	211.3	6.9	.2	.247	.255
370	830	468.8	483.5	.06835	.06335	14.62	14.62	205.9	0	205.9	0	0	.248	.248

Thermodynamic *Diagrams* For Hydrocarbons

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GRAPHICAL representation of data is so widely used by every industry that the utility of this tool needs no recommendation. In the petroleum industry every laboratory and engineering department has its file of charts upon which are shown various functions of vapor pressure, molecular weight, viscosity, boiling point, specific heats, etc.

For years the refrigeration engineers and the power engineers have used Temperature-Entropy Diagrams and Mollier diagrams depicting heat effects for changes of state of the common refrigerants, and for steam. These charts have been enormous time savers for these technical men but in addition have another advantage which is tremendously important, at least for those men who have a fragmentary knowledge as to what occurs during let us say, a throttled expansion. This advantage is that on a Mollier diagram or on a Temperature-Entropy diagram a change of state can be followed pictorially through all its stages to the final point, and all the changes in pressure, temperature, or entropy actually can be seen. In this way nebulous quantities such as entropy become clearer with habitual usage of the diagrams and eventually the user unconsciously obtains a good understanding of the formerly hazy concept.

Use of these charts in the petroleum industry has been retarded by two main factors. The first, and most important retarding influence, has been the lack of data on hydrocarbons in the higher molecular weight ranges. This lack however, is rapidly disappearing, and, while we are only on the fringe of knowledge concerning the thermal properties of hydrocarbons, yet enough material has been published within the past few years so that engineering calculations now can be made on almost any type of oil. These calculations, it is true, are for the most part not academically exact, but they do afford information exact enough so that equipment can be built and operated scientifically, rather than by guesswork or rule of thumb methods. For example, several articles have been published in the last three years containing data on the total heats of gasolines, naphthas and kerosenes. From the experimental data contained in these articles it is not only possible, but facile to draw Mollier diagrams and Temperature-Entropy Diagrams for these materials, and thus simplify computations now made with difficulty.

The second retarding influence to the full use of thermal data in such form as Temperature-Entropy Charts, has been the feeling in the minds of many that properties such as entropy and enthalpy (heat content) are difficult to use, because they are difficult to understand.

In exposition of the use of entropy in graphical form, two charts have been constructed for ethane, using a part of the data on this compound which appeared in the May 1935 issue of THE REFINER, plus the most reliable and convenient specific heat equations for ethane vapor. Values for the entropy of the liquid and vapor have been calculated from the total heat data and heats of vaporization at different pressures. The method of computation is shown here by a sample calculation. Data similar to that published on ethane in THE REFINER are available for many of the pure hydrocarbons, as well as for several oils ranging from gasolines to tars. Heat content, temperature, pressure, and heat of vaporization were the only variables needed to construct the two charts which accompany this article, likewise the same data on mixtures such as gasoline would allow similar charts to be made.

Figure 1 is a Temperature-Entropy chart constructed from the above mentioned data. Its utility will be discussed in the latter part of this article.

METHOD OF CONSTRUCTING CHARTS

1. *Liquid Line.*

For the change of entropy of a liquid, the equation

$$\Delta S_{LIQUID} = \int_{T_{BASE}}^{T} C_P \, dT \Big/ T$$

is used. Since the value for the specific heat of ethane liquid is not constant, it is necessary to divide the liquid heat content data into several divisions, then add the several entropy changes cumulatively to secure the final value for the entropy of liquid at the critical. As an example, the value for the entropy change between 446 degrees and 456 degrees Rankine* is calculated as follows:

To raise the temperature of ethane liquid from 446 to 456°R., a heat input of 7 B.t.u. is required. (From the data in THE REFINER.) The specific heat of the liquid for this temperature range is therefore 0.7, and Δs is calculated by using the integrated form of the equation shown previously. The value for Δs obtained in this way is added to the total of the Δs's found up to 446°R., and the same cumulative method is pursued on up to the critical.

$$\Delta S_{446-456} = 0.7 \times 2.30259 \times .009630 = .01552$$
$$S_{456} = S_{446} + .01552 = 0.1999 = S_{456}$$

In carrying out this method of calculation it is well

*(Ed. Note: The Rankine scale of temperature is the absolute Fahrenheit scale.)

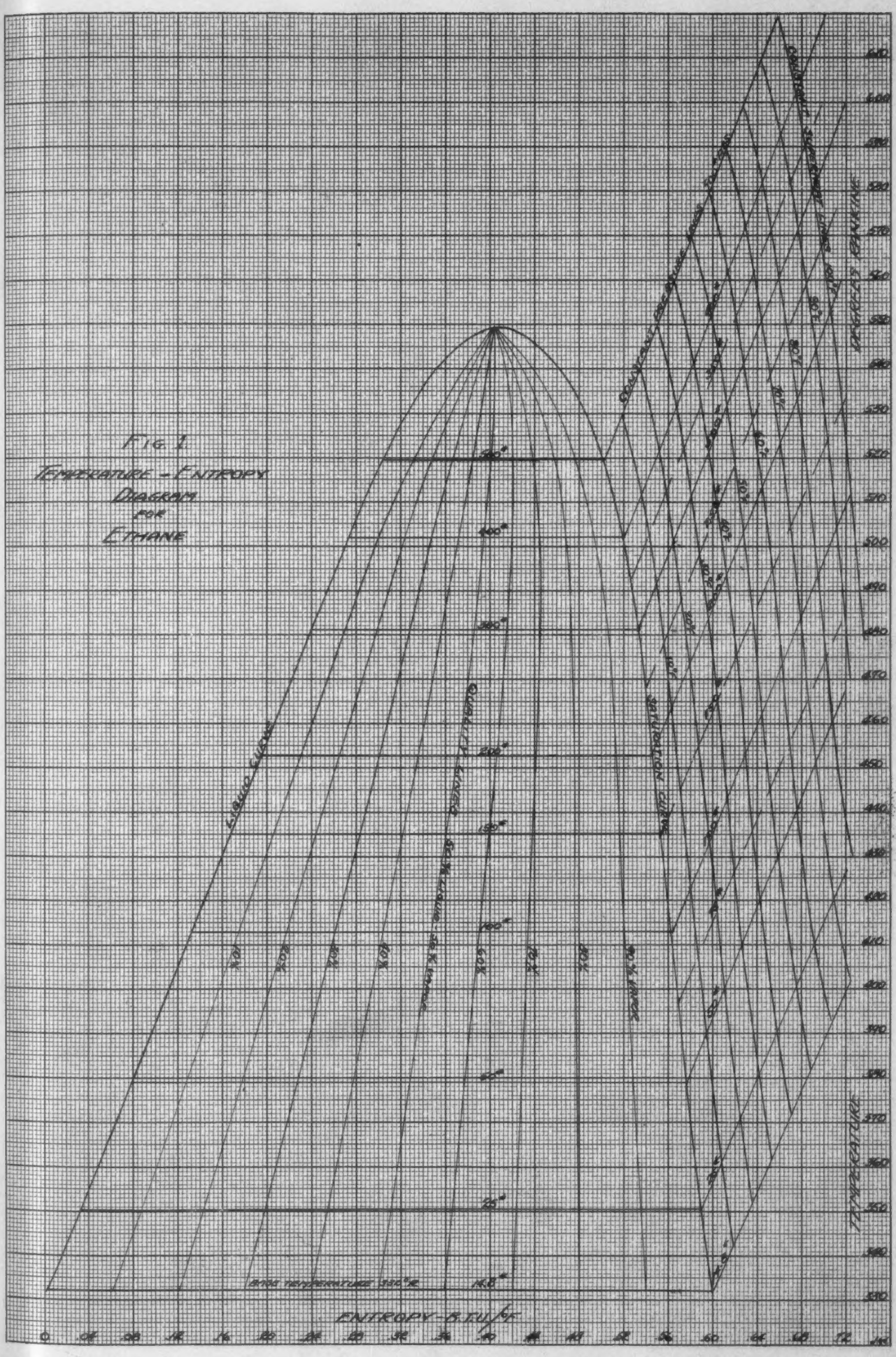
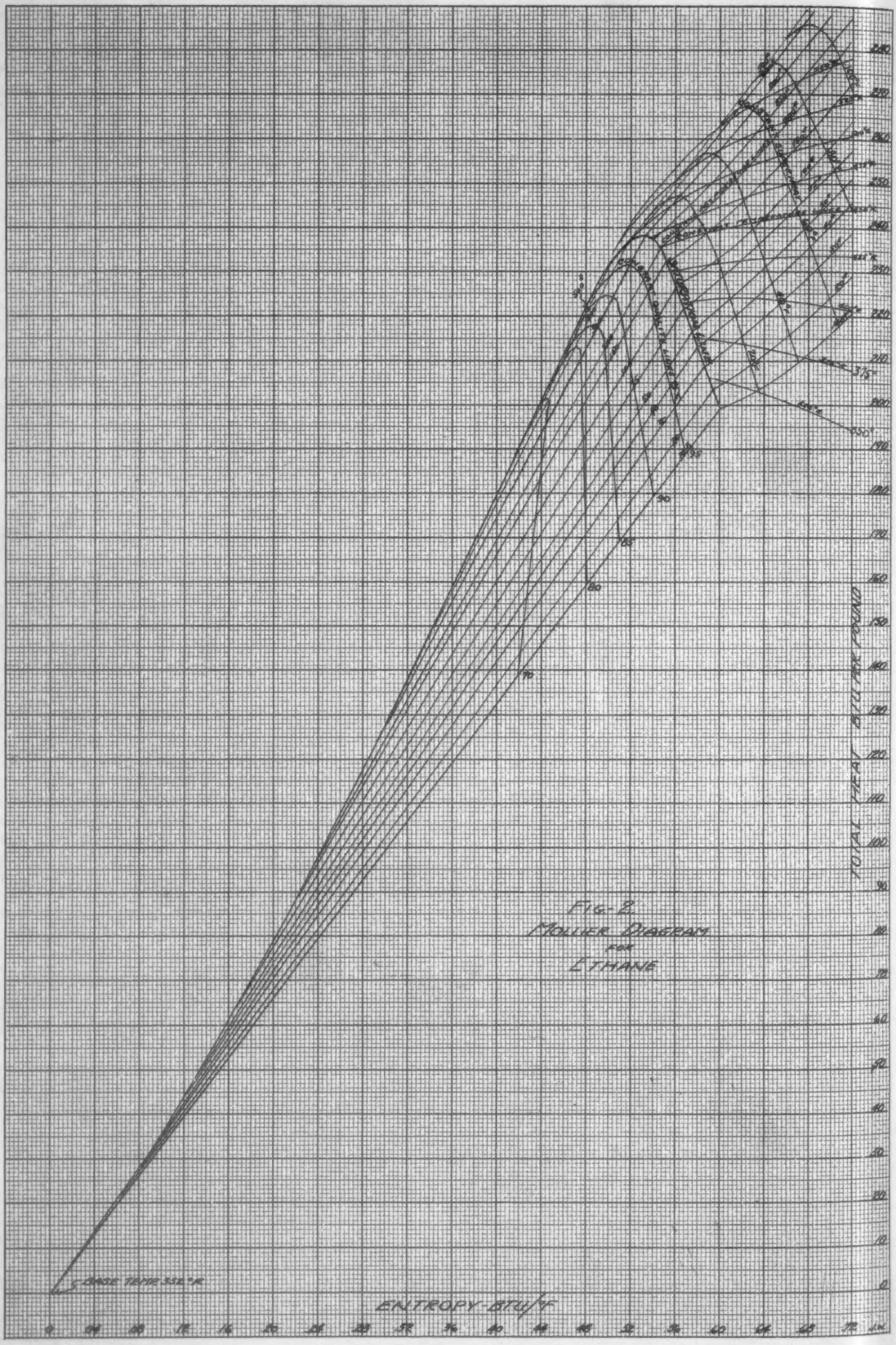


FIG. 1.
TEMPERATURE - ENTROPY DIAGRAM FOR ETHANE


TOTAL HEAT ABOVE -40° F. GROUND
ENTROPY - BTU/°F
Fig. 2.
Mollier Diagram
for
Ethane

to remember that errors are cumulative so a log table is better than a slide rule. By making the subdivisions chosen for the liquid heat content interval smaller, any desired degree of accuracy is obtained.

2. *Saturation Line.*

In a reversible process such as vaporization, the change in entropy is equal to the heat effect divided by the absolute temperature at which the vaporization occurs, or L/T. Therefore the heat of vaporization divided by the temperature of vaporization, plus the entropy of the liquid at that temperature, (previously calculated in 1.) gives the entropy of the saturated vapor.

Example

The entropy of the liquid at 456 degrees Rankine, using the method in 1, was found to be 0.1999. L, the heat of vaporization is given as 157.7 B.t.u./lb., and $\Delta_{\text{VAPORIZATION}}$ is 157.7/456 or 0.346. The entropy of the saturated vapor is therefore 0.1999 plus 0.346 or 0.5459.

3. *Constant Quality Lines.*

Since entropy is additive it is only necessary to multiply the $\Delta_{\text{VAP.}}$ found in 2, by the desired fraction of vaporization, and add to the entropy of the liquid at that temperature as found by 1. For 80 percent quality at 456 degrees Rankine we get,

$$(0.80 \times 0.346) + 0.1999 = 0.477$$

entropy of the 80 percent vaporized mixture.

4. *Superheated Vapor Lines of Constant Pressure.*

These were calculated from specific heat equations for ethane at various pressures. A slight incongruity occurs at the connecting points where different equations were used but the disparity is not as large as might be expected. For example, on the Mollier diagram the constant temperature lines in the low pressure superheat area slope downwards when it is probable that they should be nearly parallel to the entropy axis.

5. *Constant Superheat and Constant Temperature Lines.*

The method of drawing in these lines is self evident after the discussion of points 1, 2, 3, and 4.

Figure 2 is a Mollier diagram which has been drawn from the same data used in constructing the Temperature-Entropy Diagram. The information appearing on the two charts is identical with the exception of the lack of constant Enthalpy lines on Figure 1. These could have been drawn in with a small amount of extra computation but were omitted for the sake of diagram clarity since the Enthalpy can be calculated from the Temperature-Entropy chart for any desired state of the subject material.

USE OF CHARTS

Several problems on changes of state will be solved from the charts in order to show their utility.

Problem 1. Temperature-Entropy Chart.

What amount of heat must be added to one pound of ethane liquid at minus 80.6°F. in order to completely vaporize it at 300 pounds pressure absolute?

Solution:

On the Temperature-Entropy chart, heat quantities are represented by areas and in order to calculate an increase or decrease of heat content occurring in a change of state it is only necessary to find the decrease or increase of area passed over by the line representing the change of state.

(a) Area under liquid line from minus 80.6°F. to 20.4°F. (assuming liquid line forms a triangle with the base line) is:

$$(0.24 - 0.08) \times (21.4 + 80.6)/2 + 379\,(0.24 - 0.08) = h_{\text{LIQUID}} \text{ or } 69.5 \text{ which is expressed in B.t.u.}$$

(b) Area under vaporization curve at 300 lbs. is,

$$481 \times (0.533 - 0.24) = 140.7 \text{ B.t.u.}$$
$$140.7 + 69.5 = 210.2 \text{ B.t.u. ANSWER}$$

Problem 2. Temperature-Entropy Chart.

What is the theoretical thermal efficiency of a system containing ethane and operated as follows: Ethane liquid at minus 128°F. is heated to 21.4°F. and vaporized. It is then superheated 20°F. and expanded in an engine reversibly and adiabatically to 14.8 pounds absolute pressure, and the existing vapor condensed at that pressure?

Solution:

(a) Area under liquid curve,
$0.24 \times (481 - 332)/2 + 0.24 \times 332 = 97.6$

(b) Area under vaporization curve,
$(0.533 - 0.240) \times 481 = 140.7 = L$ or ht. of vaporization

(c) Area under superheated curve,
$(0.564 - 0.533) \times 481 + (0.564 - 0.533)20/2 = 15.2$

Total heat input,
$97.6 + 140.7 + 15.2 = 253.5$ B.t.u.

Heat rejected at 14.8 pounds abs.,
$0.564 \times 332 = 181.7$ B.t.u.

Efficiency: $(253.5 - 181.7)100/253.5 = 28.3$ percent.

Problem 3. Mollier Diagram.

A mixture of 95 percent ethane vapor and five percent liquid at 85.3 pounds gauge pressure is expanded through a valve to atmospheric pressure of 14.8 pounds absolute. What is the condition of the resultant superheated vapor?

Solution:

Expansion through a valve is a Joule-Thomson expansion and therefore occurs at constant total heat. Follow the constant total heat line from its intersection with the 100 pounds absolute pressure line, and the 95 percent quality line, across the diagram to the right until the 14.8-pound line is reached. The ethane at this point exists as superheated vapor and is at minus 70°F., or at 62° superheat.

Problem 4. Mollier Diagram.

Fifty-seven pounds of ethane vapor at 200 pounds pressure absolute and 475° Rankine is expanded reversibly in an engine to 30 pounds absolute without appreciable loss or gain of heat. What is the work done by this expansion? What is the quality of the resultant mixture?

Solution:

In an adiabatic reversible expansion no entropy change occurs. The heat content of the ethane before expansion is read from the chart as being 242.5 B.t.u. per pound. Following down the constant entropy line to the 30 pounds absolute line, the heat content is found to be 206.5 B.t.u. per pound. The available work is obtained by subtracting the lower value from the higher or,

$242.5 - 206.5 = 36$ B.t.u. work per lb.
$36 \times 57 = 2052$ B.t.u. from 57 lbs. ethane.
$778 \times 2052 = 1{,}596{,}000$ ft. lbs. work available

Interpolating between the constant quality lines one can read off the quality of the resultant mixture as 98.5 percent vapor.

Modernization

of Louisville Plant

Effects Savings

AFTER operating its refinery for about six years with equipment revamped and reconditioned in 1929, Louisville Refining Company, Louisville, Kentucky, recently erected a new pipe still which took the place of two others built when the Dubbs cracking units were erected. When this new type of cracking plant pipe still was erected, a new hot oil pump was installed so that higher pressures could be maintained.

The stocks used in the Louisville plant are of the same general character which have been processed for a number of years and the method of topping the crude has not materially changed. (See REFINER, January, 1929, pages 75 to 82). The topped crude is taken from the skimming unit run down tanks and charged to the cracking unit with pumps which have been in service for a number of years. The gravity of the topped crude has been materially lowered by cutting deeper into the crude and the residuum from the skimming unit was running as low as 21° A.P.I. in July, this year.

The design of the original cracking units was such that they could be operated independently of each other and consequently two separate furnaces were built. Two hot oil pumps were required also, as well as other auxiliary equipment in duplicate. The topped crude charge to the older units could be run to either fuel oil or coke, as the occasion demanded. The new furnace may be operated so that similar results can be obtained.

The new setup provides for one pump operation however, which has a double discharge, one stream traveling through one bank of tubes in the furnace while another stream flows through the other bank. The streams of oil in process may converge at the furnace outlet, or they may remain separated to be directed to either cracking unit. The new horizontal pump is driven by a horizontal steam engine directly connected to the gear shaft of the pump through flexible metallic couplings.

The reaction chambers are operated independently, but the dephlegmators which are placed on high steel towers have a common leg, each one being tied to the other some distance above the ground level. One of the reaction chambers is lined with a ceramic material while the other has been sprayed with aluminum to prevent internal corrosion due to hydrogen sulphide.

The new furnace, placed in operation in December, 1934, was designed as a 20,000,000 B.t.u. unit, being double fired through 24 tunnels, six on each side. Gas is used as fuel. It was built without a preheater or blower. The stack is four feet in diameter and 90 feet high.

The charged stock is picked up by the horizontal outside piston packed steam driven hot oil pump and delivered to the insulated discharge lines under a pressure of 380 pounds. Each side of the pump discharges its load of oil to the furnace, and each stream enters its respective side of the furnace. The double convection bank consists of 54 tubes, 30 feet in length, made of carbon steel, three inches outside diameter and 2⅜ inches inside diameter. The effective length of the tubes is 28 feet 4½ inches, and the double bank has an effective total area of 1200 square feet. New type steel headers are used on the tube banks which permit ease of entry when it is necessary to clean out.

The streams of oil flow through the convection bank; then flow upward to the roof tubes. These tubes are placed flat in the roof instead of being inclined, one set on each side of the furnace. Each bank of roof tubes consists of 20 tubes, having a combined heating surface of 892 square feet, a total of 40 tubes with an effective length of 28 feet 4½ inches. As the oil leaves the roof tubes, each stream continues downward on opposite sides of the furnace and enters the two sets of floor tubes placed in the bottom of the combustion chamber. Fourteen tubes are placed in each section of this part of the furnace with the outlet of each near the center of the unit. The heat applied to the floor tubes may be regulated by adjusting the air through the tunnels; the upper adjustment driving the flame downward, while the lower relieves the floor tubes of some of the furnace temperature. Each bank of floor tubes has an effective area of 312 square feet of heating surface.

The furnace was designed with a rated capacity of 1400 barrels of topped crude, with a recycle ratio of 3:1, making a total feed of 5400 barrels daily, but the plant has been stepped up to 2000 barrels at times, making a total feed to the furnace of 8000 barrels without apparently affecting the efficiency of either the furnace or the other units of the cracking plant.

When the older type of equipment was operated, the discharge pressure on the hot oil pumps was maintained at 280 pounds to obtain an operating pressure of 150 pounds. This method of running

the pipe stills resulted in a pressure drop of 130 pounds through the furnace and equipment. The temperature required in the furnace was 1730°F. above the tubes, to obtain an outlet, or transfer temperature of 915°F. The fuel requirements of the older type furnaces was 11 percent of the charge.

The tubes in the original furnaces were four inches outside diameter and 3⅛ inches inside. With a top charge of 1800 barrels, the velocity was slow enough through the tubes to cause considerable coking. They were turbined each time the units were taken down for a clean out. The velocity through the new tubes is much faster, and it has been found that with the same outlet temperature, a minimum amount of coke is deposited, and longer runs may be obtained without a large pressure drop through the unit.

When the cracking plant was operated with the older type of equipment and furnaces, an average charge of 1800 barrels of topped crude pumped through the plant showed the plant breakup as follows:

	Percent
Stabilized Pressure Distillate	38
Bottoms	4
Residuum	49
Gas	9
Total	100

To obtain these results, the fuel used, as stated above, was 11 percent of the charge, and consisted of fuel oil and gas from the vapor recovery plant.

With the new furnace, the breakup of the charge shows the following:

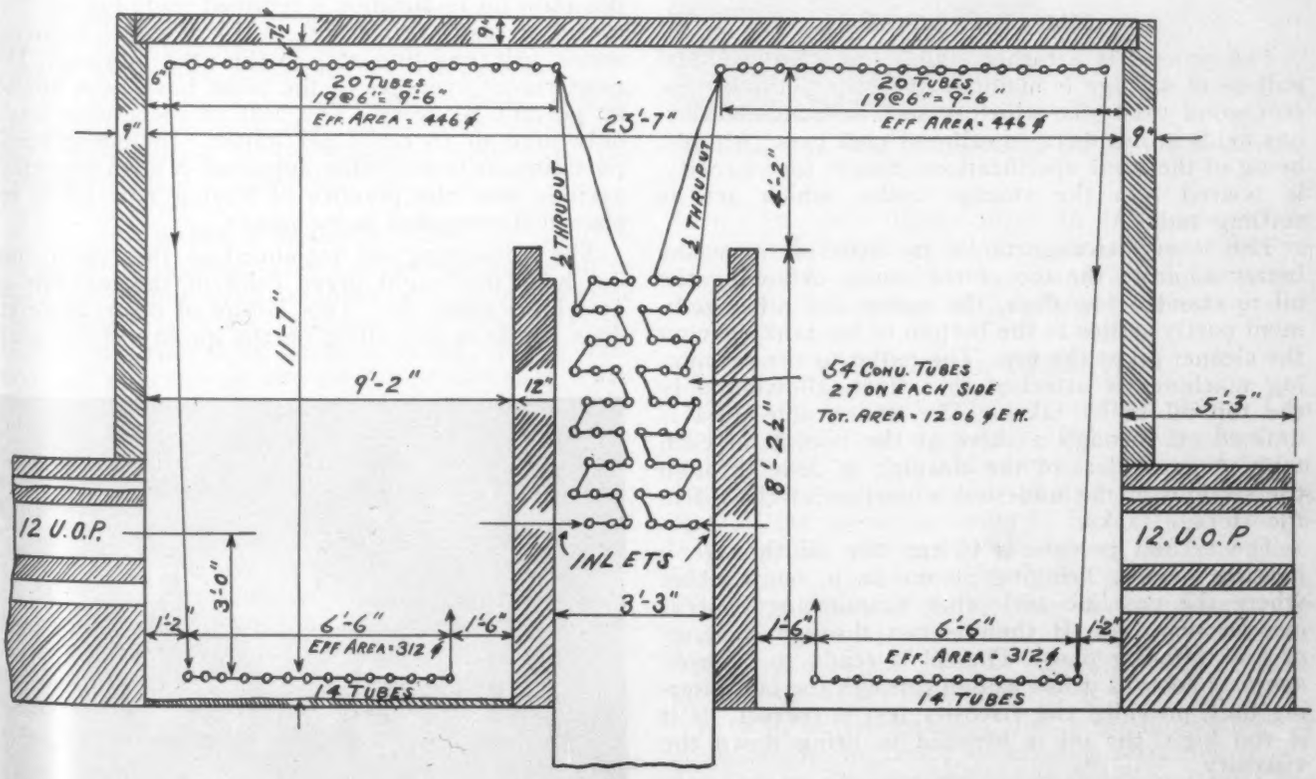
	Percent
Stabilized Pressure Distillate	40
Bottoms	3
Residuum	48
Gas	9
Total	100

To obtain this breakup, only eight percent fuel is required, as compared to the 11 percent used in the older type furnaces.

The savings effected through the use of the new furnace are easily calculated. With the new type furnace, the two percent more stabilized pressure distillate recovered represents 40 barrels, based on a 2000-barrel charge, which represents an increased yield of 1680 gallons. This amount of higher anti-knock pressure distillate represents a considerable increase in the operating revenue of the plant. The one percent less bottoms represent a 20-barrel decrease, while the residuum from the plant has also shrunk a like amount.

Not only have the more or less undesirable fractions been reduced appreciably, but the operation of the plant has been simplified, according to the operators, who say that their work has been cut in half. In the operation of the new equipment, the furnace temperatures were materially reduced to obtain the same outlet temperature. The hottest point in the furnace is about 1360°F., showing a reduction of 370°F. over the older type operation.

The reduction in fuel requirements also is considerable. If the fuel is gas, and that is the fuel used in the new still, the extra three percent of the charge may be used for boiler fuel.



Showing flow and location of tubes in furnace at Louisville Refining Company's plant at Louisville, Kentucky

Reclamation of Lubricating Oils

Air Service Practice

MAJOR R. B. WALKER
Engineering Officer, San Antonio Air Depot, Duncan Field, Texas

THE United States Government is reclaiming tens of thousands of gallons of airplane motor lubricants every year, effecting an important saving to the army as well as producing a high quality oil. This work has passed the experiment stage and now is considered a necessary cog in the machinery running the air division of America's defense.

Duncan Field, Texas, maintains one of the largest of these reclaiming units, having an annual throughput of between 50,000 and 60,000 gallons of oil. This lubricant is used in airplanes operated in the Eighth Corps Area, centering mostly around San Antonio, but including points as far east as Barksdale field in Shreveport, Louisiana, and as far west as Denver, Colorado.

This work, done in such volume, provides information concerning the adaptability of reclaimed oil to use by operators of fleets of trucks, airplanes, etc., in other than army circles. Studies along this line, prove that there is a definite relationship of the oil to be reclaimed and the finished product. If the product to be reclaimed is a poor grade stock, or is a conglomerate of poor and good oil, the result will be at the best only a fair lubricant.

In the Duncan Field plant utmost care is taken to protect the lubricant and keep it up to the specifications provided by the United States Government for use in airplanes. As a result, it is believed that the reclaimed oil compares favorably with the new oils used in the service.

SIMPLE PROCESS

The process is a rather simple one. Some 25,000 gallons of storage is maintained in the plant for the storage of used oils, which is sent in from the various fields in drums or in railroad tank cars. All oils, being of the same specifications, except for viscosity, is poured into the storage tanks, which act as settling tanks.

The several storage tanks are fitted to skim the better oil from the top of the tanks. Allowing the oil to stand a few days, the water and other sediment partly settles to the bottom of the tank, leaving the cleaner oil at the top. The outlet to the reclaiming machines is attached to a float, allowing only the top oil to be taken. The undesirable fluid is drained off through a valve at the bottom of each tank. A great deal of the cleaning is done through the settling of the undesirable portion of the oil in the storage tanks.

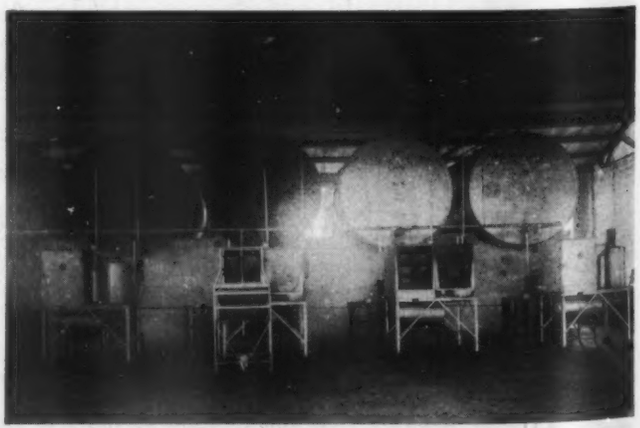
The second process is to run the oil through a heating device, bringing it up to a temperature where the gasoline and other evaporating content can be removed. It then is run through a series of four filtering pads. The oil is ready to be used again as soon as it has passed through the last filtering unit, provided the viscosity test is correct. If it is too high, the oil is blended to bring down the viscosity.

The finished product is stored in drums or a large storage tank, having a capacity of 20,000 gallons. The oil is either shipped in tank cars or in regular size oil drums, depending upon its destination.

Due to the heavy weight of the oil and its slow movement in cold weather, it has been found that the most economical way of handling it through the reclamation plant is during the summer. When the plant commences operation it runs 24 hours per day, five days per week. The sixth day is employed in re-working the equipment, cleaning and preparing for the next run. By running continuously, the machinery does not have to be reheated, etc. Also, the filtering pads are kept hot, reducing condensation. Such features as these enter into the lowering of the cost of operating this equipment.

Between 85 and 90 percent of the fluid sent into this plant for reclamation is returned ready for use. This means a loss of from 10 to 15 percent, including water, grit, gasoline, etc., in the used lubricant. The most recent averages of the plant have been around 92 percent recovery. The cost of reclaiming totals only nine to 10 cents per gallon. Including transportation costs and other expenses, it is an important savings over the practice of buying new oil to replace that once used in the planes.

The lubricating oil reclaimed in this plant does not have the bright green color of the majority of new lubricating oils. This failure of color, however, does not have any effect on the quality of the prod-



Interior of the oil reclamation plant show four unit, settling tanks and other equipment. Note arrangement of equipment to increase safety.

RECLAMATION of lubricating oil used in lubrication of various types of machinery has been growing extensively as a general practice during the past few years. Readers of The Refiner have been requesting more information on this subject and for that reason Major R. B. Walker, Duncan field, was requested to prepare the accompanying discussion of one of the government's largest oil reclaiming plants. It must be understood that the process described here is but one of many which are employed in this country and abroad. The present process is, however, one of the simplest in design and operation.

Refiners of lubricating oils in districts of dense population could well give thought to the possibility of reclamation of their own oils returned from large and constant customers. Operators of larger refineries, large compressor plants, and the like may also find that reclamation of their own products through use of such processes as the one described may prove more profitable than appears on the surface.

uct. It is possible to color it through a washing process, employing chemicals. This has been found expensive and in some cases damaging. Unless the chemicals are completely removed, it is likely that corrosion will result in the motor.

Two types of oil are used in airplanes in Duncan Field sector. They have the same basic specifications with the viscosity tests being 98 and 120 seconds Saybolt. As this oil is shipped into the plant for reconditioning, it is mixed and allowed to settle. The viscosity so materially steps up when reconditioned that it is generally above the 120 figure. A recent run showed viscosity of 126, flash 490°F., fire 560°F. This was barely within the maximum allowed under the government specifications.

The blending unit is electrically operated, lighter oils being mixed with the heavier oils proportionately, then stirred in the blending tank until the desired viscosity is obtained.

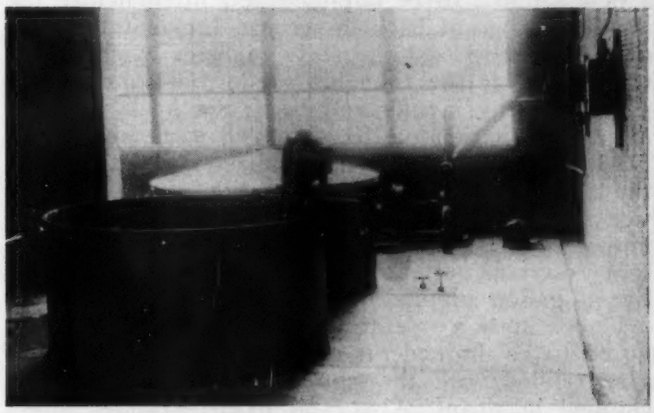
SAME SPECIFICATIONS

One of the important factors in reclaiming oil in this plant is that all of the lubricants are of the same specification, save the viscosity test. The reclamation work removes all foreign matter, water, dilution, and puts the oil into similar condition as when it was new. Lubricating oil does not burn away through use. Its loss is through wastage and intrusion of foreign materials. As a result of this, the removal of these undesired materials puts the lubricant into the same usable condition as before the oil was used the first time. The oil is constantly reclaimed until the last bit of it is gone. There is no attempt made to separate the oils, the new lubricants, used only once in an engine, are poured into the same containers with oils that may have been run through the reclaiming plant a dozen times.

Government chemists have made some very interesting discoveries concerning reclaimed lubricating oils, which may be applied to commercial work along this line. The main warning in reclaiming oil it that "the chain is no stronger than its weakest link." To use poor lubricants with better oils, conditioning the conglomerate, the best that may be expected is generally not too good. Reclaiming equipment is designed only to remove the grit, water, gasoline, etc., which may get into the oil from use and from handling.

In the case of many commercial oil reclaiming plants oils are gathered at filling stations, from operators of fleets of cars, etc. The main object to obtain volume of used oil to be reclaimed. The conglomerate includes various types of lubricating oils from different portions of the machines, as well as oils that are of little or no lubricating value. Likewise, these oils are of different qualities. When re-worked, and colored, they take on the appearance of being equal in quality to good lubricating oils on the market. On the other hand, if good lubricants are reclaimed, the results are most successful.

Safety is stressed in the Duncan Field reclamation plant. All oil movement is through pipes and oil is handled either by gravity or electric pumps. All units of the plant, including storage, are widely spaced so that access is available from all sides without the possibility of being burned on any of the heating units. In addition, cleanliness is stressed to the fullest degree, preventing injuries through falling as a result of stepping upon an oily spot on the floor. The only likely place in the plant where injuries may result is in changing the hot filtering pans. Racks to hold these pans are so arranged that a limited amount of handling is necessary.



Blending Vats. Oil is blended by electric driven stirrers.

ECONOMY IN OPERATION

Economy is another feature of the plant. This particular point is constantly studied to reduce operation cost to the minimum. It was found that life of filtering pads, one of the most expensive parts of the operation, could be increased by always installing the new pad in the last of the four filtering units and advance the other pads in rotation. The greater part of the filtering work is done in the first units, the last units being to remove the minute traces of material which may by chance work through the upper portion of the unit.

It is to be remembered that good lubricating oil is an important factor in keeping airplanes in air. Any failure of the motor while flying may cost one or more lives, hence only the best in equipment is good enough for this department of the service. This, of course, includes the lubricating oils used.

Simple Diesel Oil Drain

Fool-Proof Method Overcomes Problem of Lubrication in Pipe Line Station

ELTON STERRETT

TWICE, during the first eighteen months of operation, a main line pumping station temporarily lost the services of one of its Diesel engines; and in each case the trouble was in the crank and shaft bearings. As a result the engineers perfected a simple and fool-proof method that has overcome the problem.

Each shut-down could be traced directly to the lack of lubrication, the first being caught before the bearings were more than scorched on the surface. The second time the bearings were a total loss, and a new set had to be obtained and fitted before the unit could be put back in service. Incidentally, each shut-down also cost the shift engineer in charge of the station at the time his grade, both men being given non-pay layoffs and being set back to oilers after examination of the damaged equipment.

Although the men were penalized for the failures, the trouble came from a combination of station practice and engine design. The four-cylinder, 400-horsepower Diesels were full-pressure oiled, an engine-base reservoir serving as sump and holding the entire 40-gallon supply.

Under station operating rules, this oil was supposed to be drained off once a month, and the engine refilled with the same amount of new or reclaimed lubricant. Also, and likewise under direct orders from headquarters, when a unit due a change was operating, this draining off and replacing of the oil had to be done without shutting down.

As furnished by the manufacturer, the engine oil drain was through a hole at the junction of side wall and bottom of engine base, this being drilled and tapped to receive a one-inch pipe plug. Usual drainage practice was to remove this plug, screw in by hand a short length of pipe with valve and nipple and with a short length of hose connect this temporarily to the line leading to the oil-reclaim unit.

This draining requiring considerable time, the shift engineer was forced to attend to his other duties in the interim, checking the drop of the oil level as opportunity permitted. In both instances where bearings were damaged, yard or station emergencies demanded the engineer's entire attention, and the oil drainage was temporarily overlooked or forgotten.

After the second shut-down the oil drains were revised as shown in the sketch. A tap was run completely through the hole formerly holding the drain plug, so a tank or locknut nipple might be screwed therein. The inner end of the nipple was to hold a tee with the branch upright, and the innermost end of the run of the tee to take the plug formerly used in the crankcase drain.

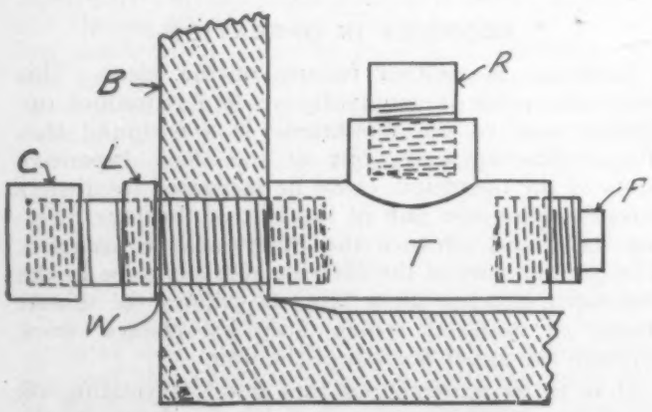
As there was not room to make up the tee inside the base (it was even necessary to grind off the fitting slightly at the end to provide the required clearance) the nipple was screwed into the tee at the same time it was put through the base. By holding the fitting with the branch horizontal while running in the nipple, and then screwing it on a quarter-turn to bring the branch upright, a tight joint was assured.

The outside of the nipple was sealed against oil leakage with a gasket, "W", held in place by the lock collar, "L", and a cap used to close the outer end of the revamped drain.

Experiment having shown that a four-gallon supply would keep the oil pump filling with the engine running, this amount was doubled to provide a factor of safety, and a short nipple or riser, "R", screwed into the branch of the tee with its upper edge so set as to retain eight gallons of oil in the reservoir when drained down to the lip of the riser.

The plug, "P", in the inside of the tee could be reached for removal only by shutting down the engine and opening the crankcase, and only by its removal could the safety supply of oil be drained off. With the lower inlet of the tee plugged, ordinary oil changing could be carried on as per the former schedule, but with the important difference that now, even though forgotten or pushed aside by the press of other duties, it was impossible to drain the oil below a safe level.

Since improving the engine oil drains in accordance with the plan sketched, there has yet to be a minute of lost time chargeable to engine lubrication failure; nor, by thoroughly cleaning the oil reservoir each time the engine valves were overhauled, was it found necessary to introduce fresh oil more frequently than when the entire supply was renewed.



Sketch of method used to "fool-proof" Diesel engine oil drain. (Not drawn to scale.)

B—Engine Base
C—1" Pipe Cap
L—Locknut
W—Gasket
P—1" Pipe Plug
T—1" Tee
R—Riser Nipple

Inspection of
Oil Refinery Equipment

PART 5

FRANKLIN L. NEWCOMB

Supervising Engineer, Safety Inspection Division, General Engineering Department, Standard Oil Development Company

A LIMITED number of reprints of this series of five articles will be ready for distribution shortly at a price of $1.00 each. This valuable work has proven very popular and following publication of the notices regarding availability of reprints orders have been coming in from all parts of the world. There has been no other treatment of the problems of inspection of refining equipment prepared for publication and in all the petroleum literature only in The Refiner has such a comprehensive study of inspection and inspection problems been available. Of such splendid reception The Refiner is appreciative, but is none the less cognizant of the thanks due F. L. Newcomb for his willingness to cooperate to the extent that the refining industry may have this important information permanently in the literature.

LIMITS FOR DISCARDING EQUIPMENT

DETERMINATION of the safe allowable operating pressure or the minimum permissible thickness for a given pressure, for any piece of equipment, is an essential function of an inspection organization. Every engineering inspector should be familiar with the proper methods for determining the above for any equipment he may inspect. On the other hand, every inspector should be supplied with tables or curves of minimum limits and allowable operating pressures, covering as many cases as possible, so as to avoid delay in returning equipment to operation.

In determining the allowable pressure for any piece of equipment, it is necessary to consider:

1. The character and inherent hazards incident to the contents of the equipment since, the greater the inherent hazards, the more care must be taken to prevent even small losses and leaks.

2. The temperature and pressure involved, because the temperature affects the strength of the material of construction and the pressure is the primary factor in determining the required thickness of material to prevent rupture.

3. External strains, since they may be additive to those caused by the pressure and thus affect the required material thickness.

4. The type of construction, since it determines the magnitude of the stress caused by a given set of conditions.

5. The material of construction, in order to know the physical properties and determine the permissible stresses.

Obviously, it is not possible to give tables of limits covering such a multiplicity of equipment as is found in an oil refinery. However, it is possible to outline methods for determining allowable operating pressures of the more common equipment used. Where legal codes, covering specific types of equipment are in force, they must be followed in making strength calculations. Any methods outlined later should be ignored if they conflict with existing legal codes.

PRESSURE VESSELS

The two most widely recognized codes for pressure vessels are those of the American Society of Mechanical Engineers known as the "Power Boiler Code" and the "Unfired Pressure Vessel Code." However, it was recognized that petroleum pressure vessels required some special features not covered by the above two codes and it was not intended that petroleum pressure vessels should be subject to these codes. On the other hand, in the absence of any recognized code for petroleum vessels, they were an excellent guide to good construction, and the formulae given assured a sufficiently strong vessel. These two codes still should be considered as the authority for determining the allowable working pressure for vessels in services they are intended to cover.

Recently the American Petroleum Institute and the American Society of Mechanical Engineers jointly have issued the "API-ASME Code for the Design, Construction, Inspection and Repair of Unfired Pressure Vessels for Petroleum Liquids and Gases." As the title indicates, these rules have been carefully formulated to care for all of the special conditions incident to petroleum pressure vessel service. They cover both welded and riveted vessels and it is probable that an additional section covering seamless forged vessels will be issued some time in the future. These rules go further than any former pressure vessel codes since they provide for the periodic inspection of these vessels, give rules covering repair and are explicit as to the methods to be used in determining the allowable working pressure throughout the life of the vessel. They also give rules for determining the allowable working pressure of petroleum vessels constructed prior to the formulation of these rules. These rules have been compiled carefully and appear fair and reasonable. They will result, undoubtedly, in the discard of poorly designed, unsafe equipment. An effort is being made to have them adopted as legal requirements for petroleum pressure vessels in as many

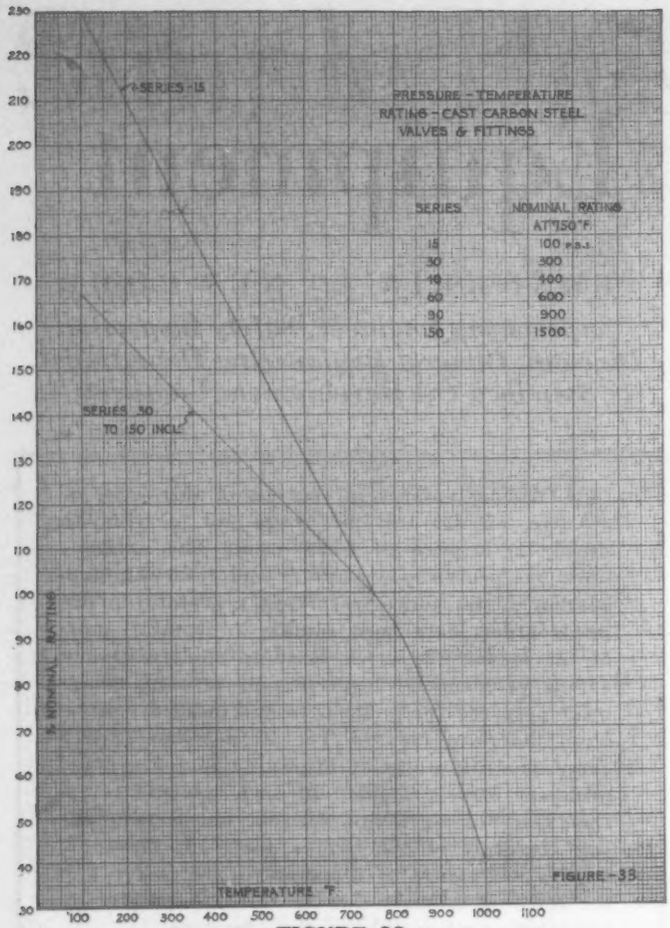


FIGURE 33

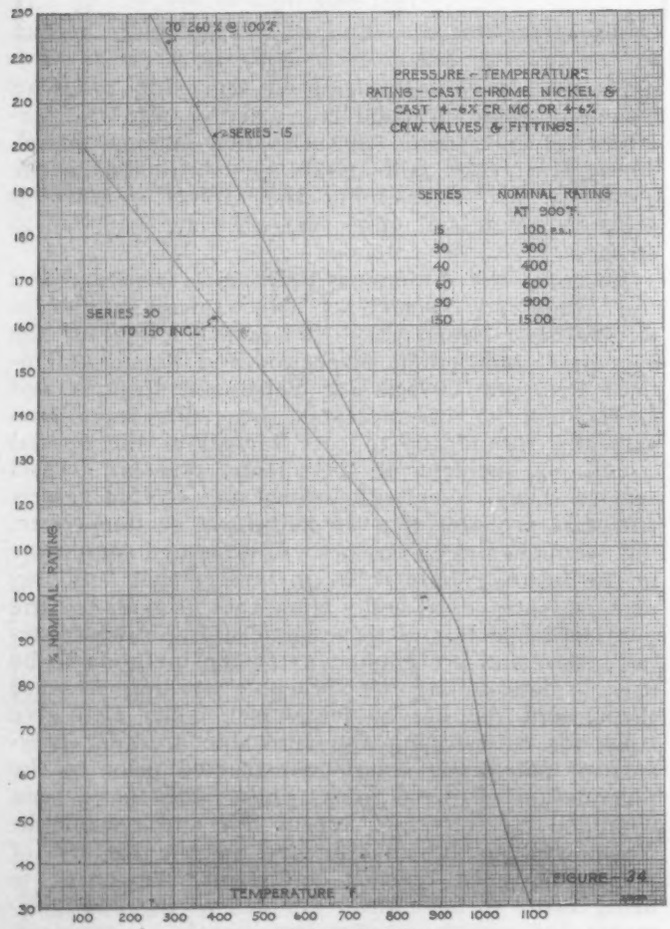


FIGURE 34

states as possible. Inspectors of petroleum vessels should endeavor to have all repairs and additions to existing equipment made in conformity with this code. A list should be made of all changes necessary to make petroleum vessels conform to this code. Allowable pressures should be determined by the rules given in the section of the code applying to the vessel under consideration.

ATMOSPHERIC EQUIPMENT

Much equipment in an oil refinery operates at anywhere from an inch or so of vacuum to several pounds pressure and at various temperatures up to 800°F. In such equipment, it is quite possible for the indeterminate stresses to be far in excess of the determinate stresses and so the proper thickness for discarding it becomes a matter of judgment and experience. If such equipment has a thickness equal to that required for 10 to 15 pounds pressure when computed by pressure vessel formulae, does not show signs of leakage during operation and bears no evidence of distortion at its supporting points due to the load carried while in operation, it might be considered suitable for continued operation.

VACUUM VESSELS

Leakage in vacuum equipment will tend to destroy the vacuum and upset operations. In addition, infiltration of air may cause internal fires which will overheat the vessel and cause considerable damage. It is therefore, necessary to maintain a thickness which will not only prevent collapse, but will assure that the vessel remains tight against leakage. Most vacuum vessels used in the oil industry are of extremely large diameter and are heavily braced inside. It is not expected that the field inspector should be familiar with the extensive computations necessary for determining the discarding limits of this equipment. Unless someone in the inspection department is entirely familiar with vacuum vessel design, the designer should be requested to specify the minimum thickness to which the vessel and bracing can safely corrode.

STORAGE TANKS

Storage tanks are generally of such large diameter that it is not feasible to design them with as large a factor of safety as is usually employed on pressure vessels. On the other hand, they are not as subject to overload conditions as pressure vessels owing to the fact that most of the stress is caused by a static load due to the height of liquid. It is, of course, necessary to keep the working stress below the yield point of the material. If the minimum thickness of any point in a tank is such that it would give a factor of safety of two when the tank is filled with water, it should be considered safe. Under these conditions, the actual factor of safety with the lighter and more hazardous oils would be considerably over two, while with the heavier and less hazardous oils it would more nearly approach two.

PIPING, VALVES AND FITTINGS

General

Until recently, there has been little to guide one in the selection of the proper grade of pipe, valve or fitting for the various temperature and pressure conditions involved and nothing to guide one as to how much corrosion could be permitted. Recently, the American Standards Association has issued the

"American Standard Code for Pressure Piping" identified as A. S. A. standard B31. This code contains one section on oil piping and others dealing with other industrial piping. It is intended to apply only to new work and does not deal with retiring thicknesses. The code contains pressure-temperature ratings for the various classes of valves, fittings and pipe. The suggestions given herein for determining the retiring thickness of valves, fittings and pipe are based on A. S. A. standard B31 with modifications.

VALVES AND FITTINGS

Figure 33 is the pressure-temperature rating curve for cast or forged carbon steel valves or fittings and Figure 34 is a similar curve for cast low chrome-nickel or cast 4-6 percent chrome-molybdenum or chrome-tungsten valves and fittings.

The suitability of a valve or fitting for a given set of conditions is dependent not only on the body thickness but also on the flange thickness, size and number of bolts and other features. It is, therefore, just as important to know that the proper class of valve or fitting is in service as it is to know that it has the required body thickness. Figure 35 is a chart based on Figure 33 and Figure 36 is a chart based on Figure 34 from which one can read directly the class of valve or fitting required for any combination of pressure or temperature. From these charts one also can read directly the maximum recommended pressure for any valve or fitting at any temperature or vice versa. Any selection made from these charts will conform with the recommendations of A. S. A. standard B31.

Based on the pressure-temperature rating curves (Figures 33 and 34) two charts covering retiring thickness for valves and fittings (Figures 37 and 38) have been prepared. These retiring thickness charts are not a part of A. S. A. standard B31. Figure 37 is used for determining the retiring thickness of cast or forged carbon steel valves or fittings and Figure 38 is used for determining the retiring thickness of cast low chrome-nickel or cast 4-6 percent chrome-molybdenum of chrome-tungsten steel valves and fittings.

These retiring thickness charts are based on the formula

$$t_m = \frac{PD}{2S} \times 1.5 \text{ where}$$

t_m = Retiring thickness in inches—except as given in the table shown on the chart.
P = Maximum working pressure in lbs./sq. in. gauge.
D = Actual O.D. of pipe in inches, of the same nominal size as the valve or fitting.
S = Allowable working stress in lbs./sq. in.

For cast or forged carbon steel valves or fittings (Figure 37) S = 7000 lbs./sq. in. at 750°F. and is varied from this point, for other temperatures, in accordance with the percentages shown on the pressure-temperature rating curve of Figure 33.

For cast low chrome-nickel and cast 4-6 percent chrome-molybdenum or chrome-tungsten steel valves and fittings (Figure 38) S = 7000 lbs./sq. in. at 900°F. and is varied from this point, for other temperatures, in accordance with the percentages shown on the pressure-temperature rating curve of Figure 34.

Since there are indeterminate stresses in valves and fittings due to line strains and other causes, there should be an arbitrary minimum thickness below which a valve or fitting of given size should

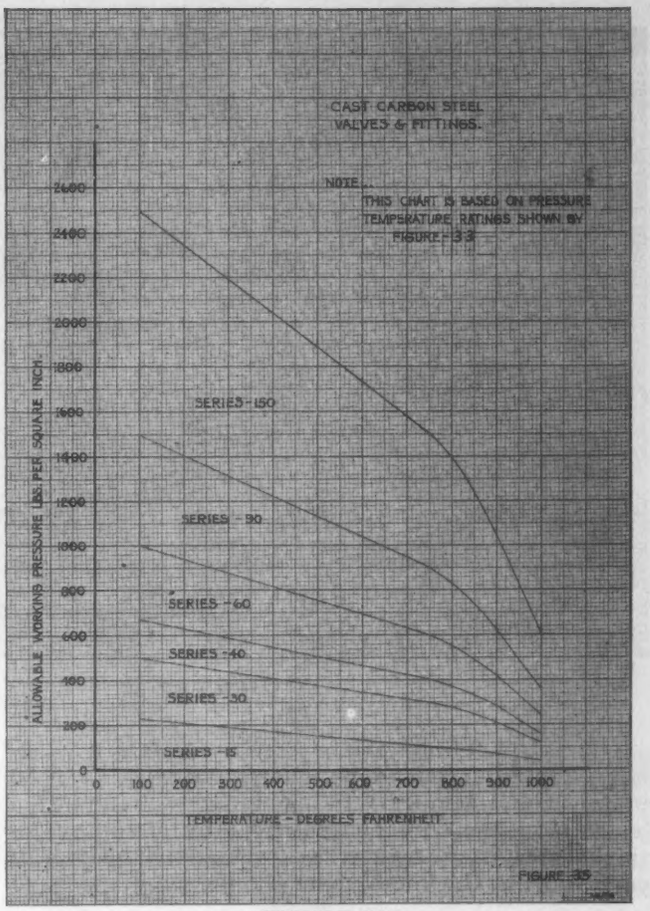


FIGURE 35

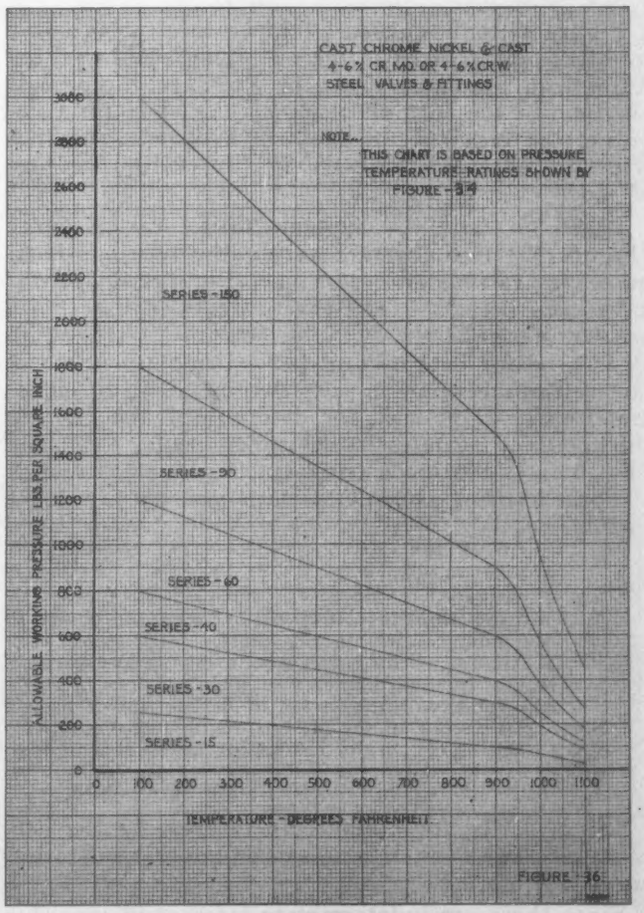

CAST CHROME NICKEL & CAST
4-6 % CR. MO. OR 4-6 % CR.W.
STEEL VALVES & FITTINGS
NOTE...
THIS CHART IS BASED ON PRESSURE
TEMPERATURE RATINGS SHOWN BY
FIGURE - 34
SERIES - 150
SERIES - 90
SERIES - 60
SERIES - 40
SERIES - 30
SERIES - 15
ALLOWABLE WORKING PRESSURE LBS. PER SQUARE INCH
0 100 200 300 400 500 600 700 800 900 1000 1100
TEMPERATURE - DEGREES FAHRENHEIT
FIGURE 36

FIGURE 36

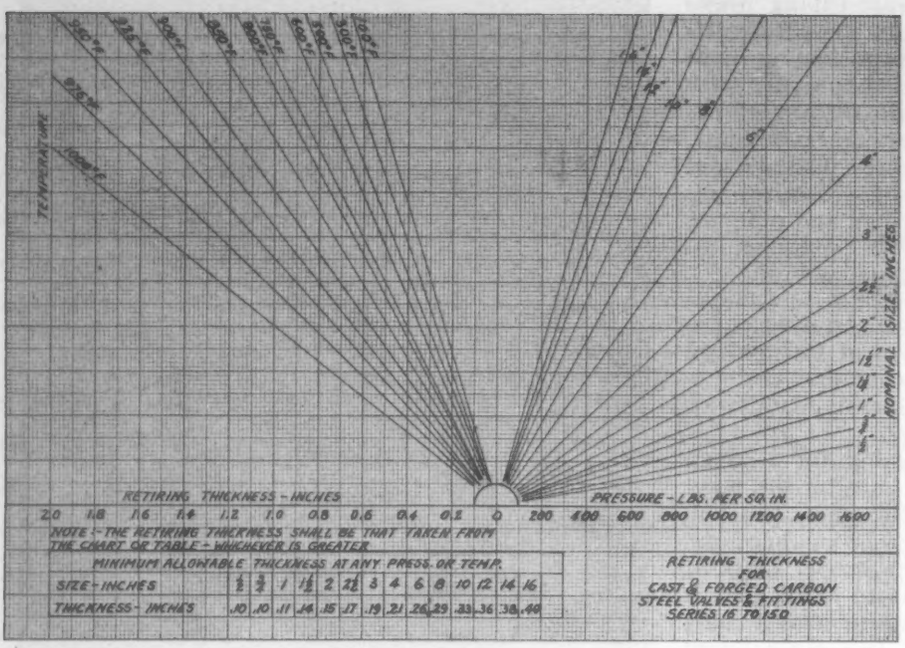

TEMPERATURE
RETIRING THICKNESS - INCHES
PRESSURE - LBS. PER SQ. IN.
NOMINAL SIZE - INCHES
NOTE - THE RETIRING THICKNESS SHALL BE THAT TAKEN FROM THE CHART OR TABLE - WHICHEVER IS GREATER
MINIMUM ALLOWABLE THICKNESS AT ANY PRESS. OR TEMP.
SIZE - INCHES
THICKNESS - INCHES
RETIRING THICKNESS FOR CAST & FORGED CARBON STEEL VALVES & FITTINGS SERIES 16 TO 150

FIGURE 37

not be used, even though computations based on pressure and temperature would seem to permit a lesser thickness. A table of such arbitrary minimum thicknesses is given at the lower left hand side of each retiring thickness chart.

PIPE

Figure 39 is the pressure-temperature rating curve for steel pipe as used in the oil piping section of the "American Standard Code for Pressure Piping." It also shows the formula used by the code for computing the required thickness of new pipe, together with the allowable stresses for the various grades of pipe.

Based on the pressure-temperature rating curve (Figure 39) two charts covering the retiring thicknesses for various grades of pipe (Figures 40 and 41) have been prepared. These retiring thickness charts are not a part of the A. S. A. standard B31. Figure 40 is used for determining the retiring thickness of lap welded steel pipe in sizes two inches to 20 inches and Figure 41 is used for determining the retiring thickness of seamless steel pipe, grades "A" and "B" in sizes 2½ inches to 20 inches.

These retiring thickness charts are based on the formula

$$t_m = \frac{PD}{2S} \text{ where}$$

t_m = retiring thickness in inches, except as given in the table shown on the chart.
P = Maximum working pressure in lbs./sq. in. gauge.
D = Actual outside diameter in inches.
S = Allowable working stress in lbs./sq. inch.
S = 12,000 lbs./sq. in. @ 750°F. for grade A seamless.
S = 15,000 lbs./sq. in. @ 750°F. for grade B seamless.
S = 9,000 lbs./sq. in. @ 750°F. for lap welded.
S = 6,250 lbs./sq. in. @ 750°F. for butt-welded.

"S" is varied for other temperatures, by the percentages shown on the pressure-temperature rating curve of Figure 39.

Since there are indeterminate stresses in pipe due to expansion or contraction, vibration, bending

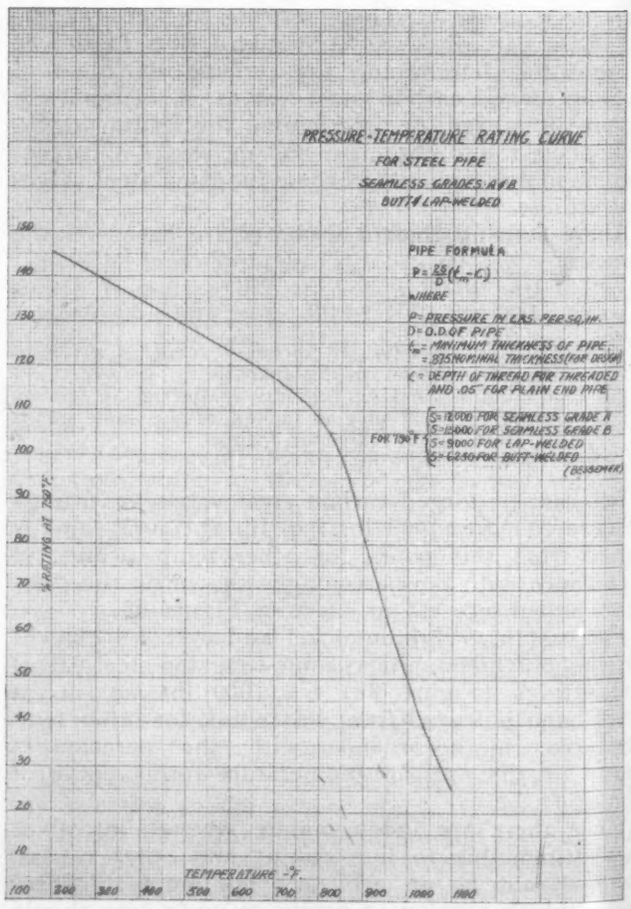

PRESSURE-TEMPERATURE RATING CURVE
FOR STEEL PIPE
SEAMLESS GRADES A & B
BUTT & LAP-WELDED
PIPE FORMULA
WHERE
P = PRESSURE IN LBS. PER SQ. IN.
D = O.D. OF PIPE
C = DEPTH OF THREAD FOR THREADED AND .05" FOR PLAIN END PIPE
S = 12,000 FOR SEAMLESS GRADE A
S = 15,000 FOR SEAMLESS GRADE B
S = 9,000 FOR LAP-WELDED
S = 6,250 FOR BUTT-WELDED (BESSEMER)
% RATING AT 750°F.
TEMPERATURE - °F.

FIGURE 39

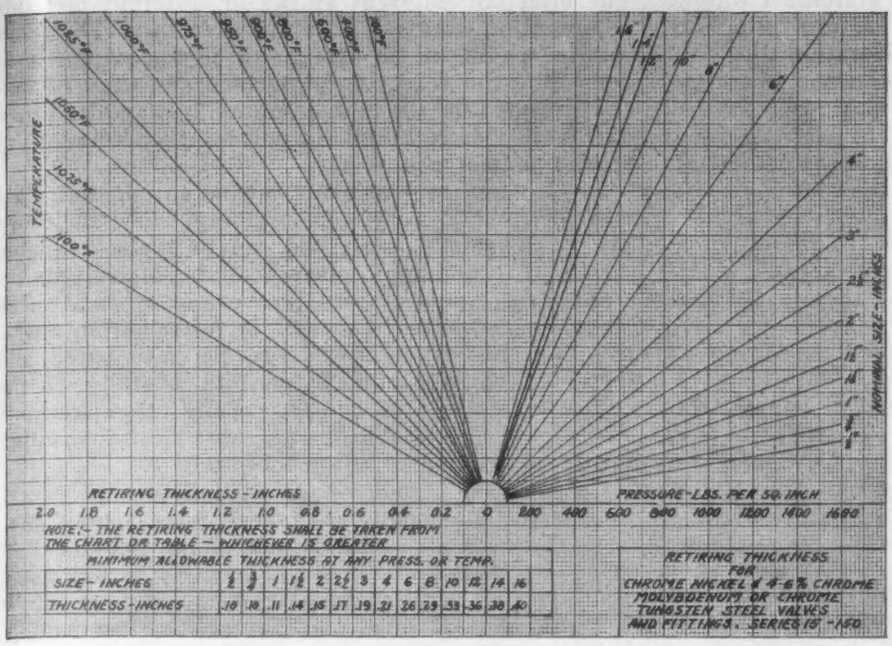

TEMPERATURE
1085°F
1000°F
975°F
950°F
900°F
850°F
800°F
750°F
1050°F
1025°F
1100°F
NOMINAL SIZE - INCHES
RETIRING THICKNESS - INCHES
2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0
PRESSURE - LBS. PER SQ. INCH
200 400 600 800 1000 1200 1400 1600
NOTE:- THE RETIRING THICKNESS SHALL BE TAKEN FROM THE CHART OR TABLE - WHICHEVER IS GREATER
MINIMUM ALLOWABLE THICKNESS AT ANY PRESS. OR TEMP.
SIZE - INCHES ½ ¾ 1 1¼ 2 2½ 3 4 6 8 10 12 14 16
THICKNESS - INCHES .10 .10 .11 .14 .15 .17 .19 .21 .26 .29 .33 .36 .38 .40
RETIRING THICKNESS FOR CHROME NICKEL & 4-6% CHROME MOLYBDENUM OR CHROME TUNGSTEN STEEL VALVES AND FITTINGS. SERIES 150 - 1500

FIGURE 38

and other causes, there should be an arbitrary minimum thickness below which the pipe should not be used, even though computations based on pressure and temperature would seem to permit a lesser thickness. These minimum thicknesses may be read from the table at the top of the charts.

The chart in Figure 41 gives the retiring thickness for grade "A" seamless pipe directly. To determine the retiring thickness for grade "B" pipe, it is necessary to divert to the right as indicated by the bracketed inclined lines at the lower left of the chart.

Charts similar to those shown can be drawn easily for smaller sizes of pipe or for butt-welded pipe. Where alloy piping is used, charts similar to those illustrated and explained, may be drawn for each different alloy, the allowable stresses at the various temperatures being chosen from the most reliable source available.

It should be noted that the same retiring thickness limits are used for either threaded or plain-end pipe. This is permissible on the assumption that the threads only reduce the strength of the pipe transversely and that when service conditions are severe enough to make this a factor, the pipe will be backwelded to the flange or fitting and all exposed threads will be covered with weld material.

VI. RESULTS OF SYSTEMATIC INSPECTION

Briefly summarized, careful systematic inspection of refinery equipment will assure safer equipment, safer working conditions, fewer accidents, more reliable and continuous operations and monetary sav-

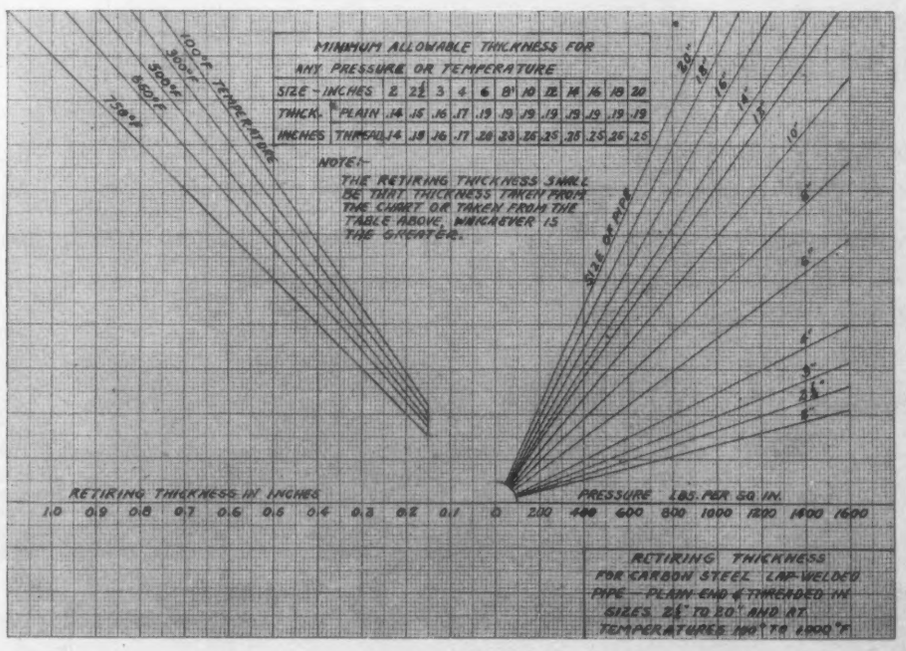

MINIMUM ALLOWABLE THICKNESS FOR ANY PRESSURE OR TEMPERATURE
SIZE - INCHES 2 2½ 3 4 6 8 10 12 14 15 19 20
THICK. PLAIN .14 .15 .16 .17 .19 .19 .19 .19 .19 .19 .19 .19
INCHES THREAD .14 .18 .16 .17 .28 .33 .26 .25 .25 .25 .26 .26
NOTE:- THE RETIRING THICKNESS SHALL BE THAT THICKNESS TAKEN FROM THE CHART OR TAKEN FROM THE TABLE ABOVE, WHICHEVER IS THE GREATER.
1000°F TEMPERATURE
900°F
800°F
750°F
SIZE OF PIPE
RETIRING THICKNESS IN INCHES
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
PRESSURE LBS. PER SQ. IN.
200 400 600 800 1000 1200 1400 1600
RETIRING THICKNESS FOR CARBON STEEL LAP-WELDED PIPE - PLAIN END & THREADED IN SIZES 2½" TO 20" AND AT TEMPERATURES 100° TO 1000°F

FIGURE 40

ings. Some of the reasons for this statement follow.

Proper systematic inspection should eliminate failures of equipment due to deterioration and consequent inability to safely withstand the operating conditions. Failures of this nature may result in loss of life, severe injuries and damage to a considerable amount of surrounding equipment. They upset operating schedules; frequently result in loss of orders, and even customers, due to inability to supply the required products until equipment is rebuilt; and have a demoralizing effect on the personnel. Aside from any monetary consideration, they should be avoided from a humanitarian standpoint.

Regular inspection keeps equipment in first class condition at all times by detecting and causing removal of deteriorated parts before they become unsafe, promptly stopping small leaks, removing or blanking off unused parts and making similar repairs. As a consequence, emergency shut-downs, with attendant loss of capacity and extra cleaning costs, are reduced to a minimum. The cost of such repair work is less than if the equipment were neglected and permitted to remain in operation until failures or major leaks occurred. The saving in loss of valuable products is also a major consideration.

Constant checking of equipment and observation of all repair work by an inspector should obviate the possibility of using improper materials when making repairs. The use of unsuitable materials may be as serious as deteriorated equipment and result in disastrous failures with the possibility of serious injuries to personnel and extensive damage to equipment.

With proper inspection records, corrosion rates can be established and the usual life of the various parts can be determined. From this, economic studies can be made to determine whether protective linings or more corrosion resistant materials are justified. The effect of different stocks or different methods of operation may be determined readily. This data is also useful in the design of new equipment to determine the corrosion allowance and kind of material needed for the best economy. It may also prove useful in determining the proper depreciation to charge against equipment.

Repairs and replacements can be anticipated. This will reduce the costs to a minimum since the work can be scheduled, materials can be made available on the site and man power can be organized. By anticipating major repairs, they can be made at times when the equipment can best be spared from operation. Capital expenditures can be anticipated and budgeted. In addition, it permits a study of the equipment in advance of repairs to determine whether or not design changes are desirable either for safety or more efficient operation.

Proper systematic inspection and prompt execution of recommended repairs will have a good psychological effect on the morale of the personnel. It gives an assurance of personal security as well as an assurance of regular operation and employment. It encourages good housekeeping with consequent diminution of accident and fire risks. It causes a man to take pride in his work and to endeavor to avoid conditions which may affect his or his fellow-workers security.

A centrally organized, coordinated inspection service transmits information on time- and money-saving methods of repair to all interested parties. It encourages a good and uniform standard of construction and maintenance. This should result in the highest practical efficiency of operation and maintenance.

Thorough systematic inspection is not "just another expense"—it is a necessity in the modern oil refinery.

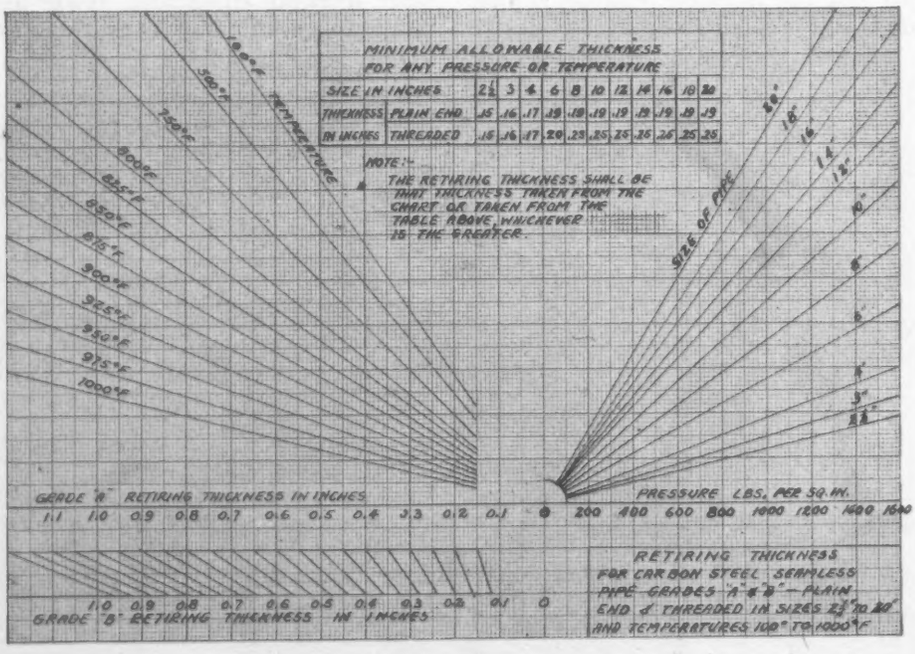
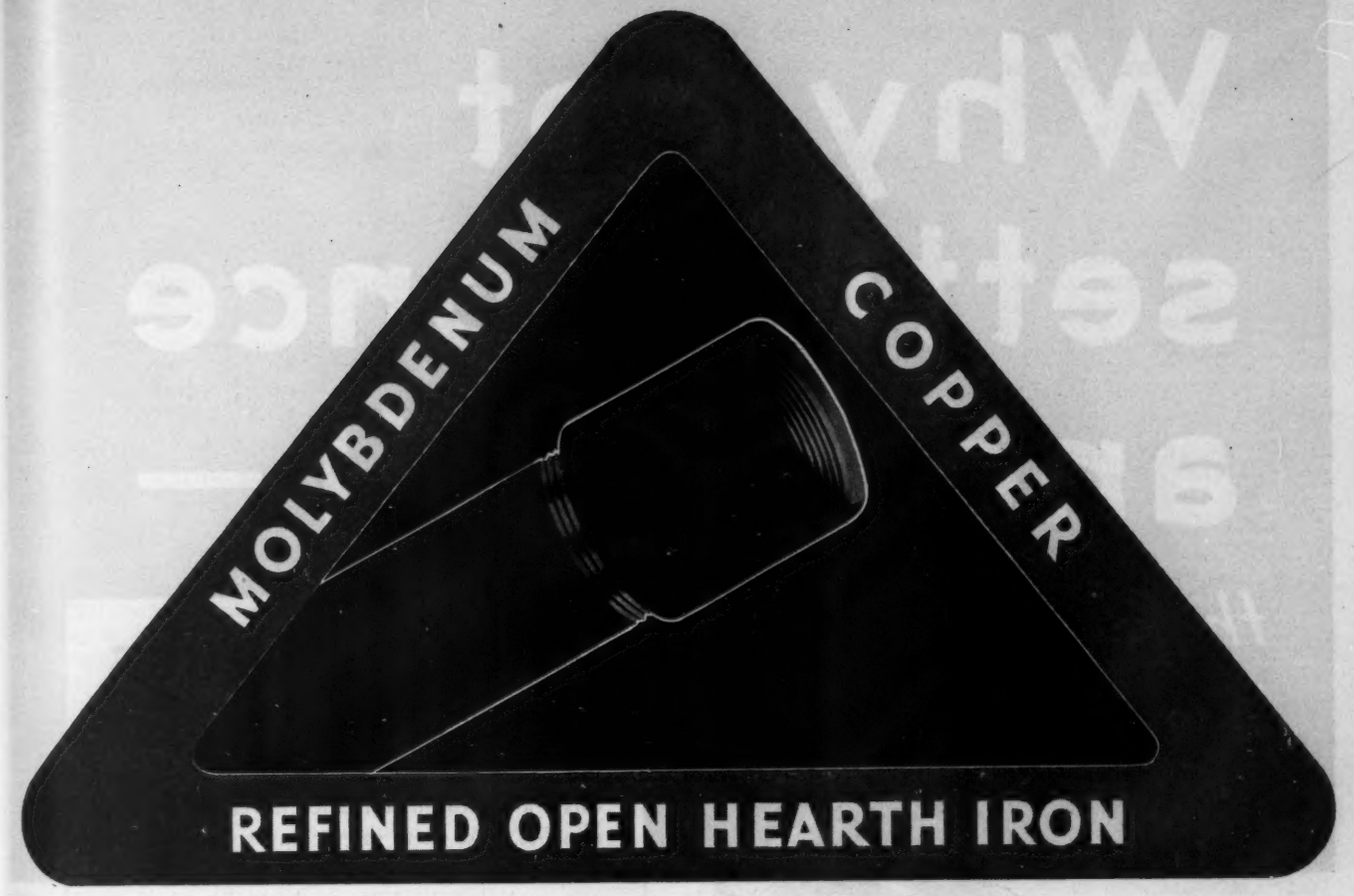

MINIMUM ALLOWABLE THICKNESS FOR ANY PRESSURE OR TEMPERATURE
SIZE IN INCHES
THICKNESS IN INCHES PLAIN END
THREADED
NOTE:- THE RETIRING THICKNESS SHALL BE THAT THICKNESS TAKEN FROM THE CHART OR TAKEN FROM THE TABLE ABOVE, WHICHEVER IS THE GREATER.
SIZE OF PIPE
TEMPERATURE
GRADE "A" RETIRING THICKNESS IN INCHES
PRESSURE LBS. PER SQ. IN.
GRADE "B" RETIRING THICKNESS IN INCHES
RETIRING THICKNESS FOR CARBON STEEL SEAMLESS PIPE GRADES "A" & "B" - PLAIN END & THREADED IN SIZES 2½" TO 20" AND TEMPERATURES 100° TO 1000°F

FIGURE 41



The Perfect Alloy for Long-Lasting Pipe

The perfect alloy for pipe manufacture is like the fabled pot of gold at the end of the rainbow—something pleasant to dream about, but impossible to attain. Metallurgists strive to find it, but two barriers block their path—cost must be kept within the accepted competitive range—and conditions of service vary to an extent that makes any prophecy dangerous.

Years of research and thousands of tests in service confirm Republic's claim that Toncan Iron is today's low-cost ferrous alloy for long-lasting pipe. It is made by combining definite quantities of copper and molybdenum with highly-refined open hearth iron to form a chemically and structurally uniform alloy. This alloy is highly and uniformly resistant to rust throughout its entire section, nor is this resistance lessened by cutting, bending or threading the metal.

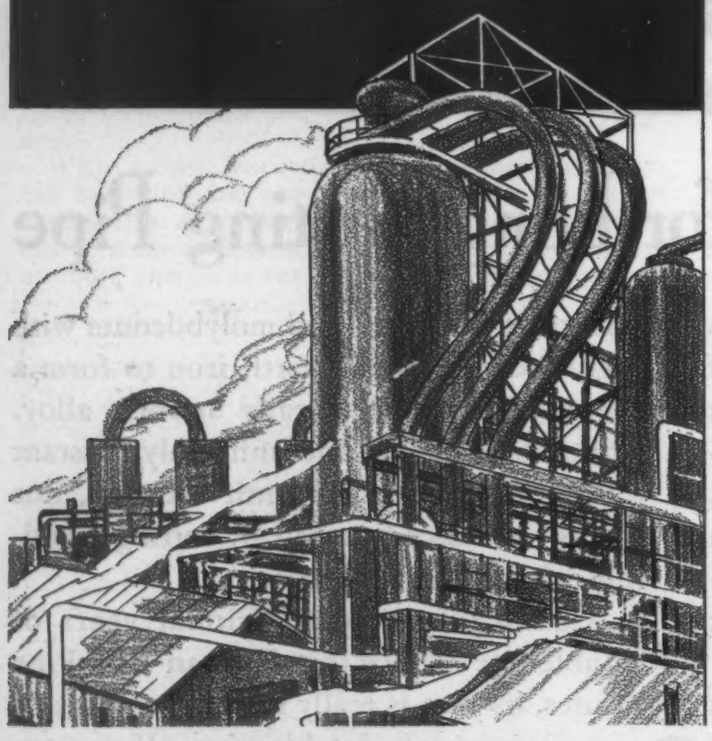
Considering the additional years of trouble-free service that Toncan Iron Pipe insures, its cost is really lower than that of less durable pipe. If you are interested in economy, use it. If you want additional information, write for a copy of "Pipe for Permanence."

Republic Steel CORPORATION

GENERAL OFFICES · · · YOUNGSTOWN, OHIO

Why not settle it once and for all —

the corrosion problem can be licked!



With NATIONAL U S S

18-8 Stainless Pipe and Tubes, those troublesome piping problems in your refinery can be settled for good. This tubular material offers a corrosion resistance never before obtainable. Use them in cracking still units, for hot oil lines, etc., where they provide safety, economy, and durability to the highest degree. Being seamless—pierced from solid billets—they have no welds, which means uniform wall-strength throughout.

NATIONAL U S S 18-8 Stainless and Heat Resisting Pipe and Tubes come in a wide range of diameters, wall-thicknesses, and lengths. They can be readily bent, welded, and otherwise fabricated. Produced with unrivaled facilities by the largest manufacturer of tubular products in the world, an organization that offers a complete piping service to the refining industry. NATIONAL engineers and metallurgists will be glad to give information as to the best application for any particular requirement. Descriptive literature sent on request.

U S S Chromium-Nickel Alloy Steels are produced under the licenses of the Chemical Foundation, Inc., New York, and Fried. Krupp A. G. of Germany.

NATIONAL TUBE COMPANY, *Pittsburgh* - - - - - - - - - - - - - **PIPE AND TUBULAR PRODUCTS**
AMERICAN SHEET AND TIN PLATE COMPANY, *Pittsburgh* - - - - - - - - - **SHEETS AND LIGHT PLATES**
AMERICAN STEEL & WIRE COMPANY, *Chicago* - - **COLD ROLLED STRIP STEEL, WIRE AND WIRE PRODUCTS**
ILLINOIS STEEL COMPANY, *Chicago* - - - **BARS, PLATES, SHAPES, SPECIAL AND SEMI-FINISHED PRODUCTS**
CARNEGIE STEEL COMPANY, *Pittsburgh* - - - - - **SHAPES, PLATES, BARS AND SEMI-FINISHED PRODUCTS**

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United States Steel USS *Corporation Subsidiaries*

USS STAINLESS

AND HEAT RESISTING STEELS

The Look Box

(*Continued from page 412*)

National Petroleum Association Meets

NATIONAL Petroleum Association, for its Thirty-Third annual meeting, Atlantic City, September 18-20, has developed an interesting program dealing with subjects of timely nature, according to announcement from the Washington office of the association. The program includes some important group conferences on various subjects. The business meetings and the annual banquet will be held at the Hotel Traymore. Friday, September 20, will be devoted to a presentation and discussion of the proposed voluntary code of marketing practices. The announcement states that year after year the programs have been of great interest and this year will be no exception.

Cracking Suit Rehearing Denied

PETITION of Root Refining Company and Winkler-Koch Engineering Company for rehearing of the cracking patent infringement suit brought by Universal Oil Products Company has been denied by the United States Circuit Court of Appeals at Philadelphia. This is the suit tried last year by Judge P. J. Niels in the United States District Court at Wilmington, Delaware, which was decided in favor of Universal Oil Products Company. The decision was upheld this spring by a three-judge circuit court at Philadelphia. The defendants asked for a rehearing on the ground that the court erred in arriving at its conclusions in interpretation of the phrase "without substantial vaporization," on the specific interpretation of which the plaintiff's case largely rested.

Chemical Engineering Congress

ARRANGEMENTS are being made to hold an international congress of chemical engineering in London, England, from June 22 to 27, 1936, it is reported in the July, 1935, issue of the Journal of the Institution of Petroleum Technologists. The outline of the program is as follows: Section A, Chemical Engineering Projects (location, lay-out, finance, raw materials, markets, etc.) Section B: Chemical engineering plant construction (materials and standards of workmanship.) Section C: Fuel, heat and general problems in chemical engineering; (1) selection of fuel and power, (2) carbonization, (3) distillation, evaporation, condensation and crystallization, (4) treatment of gases, (5) hydrogenation, cracking and other high pressure developments, (6) heat exchange and heat transference, (7) lubricants and lubrication, (8) preparation of materials on site, (9) disposal of effluents. Section D: Administration and works organization in chemical engineering (education and training of a chemical engineer, costs and statistics, safety and welfare). Section E: Trend of development in chemical engineering (synthetic products, high pressure, vacuum and temperature technique). Section F: General Aspects (the translation of semi-scale processes into commercial production).

Sir John Cadman, G. C. M. G. is a vice president of the congress. Dr. A. E. Dunstan and Dr. W. R. Ormandy are members of the organizing committee. Lieutenant Colonel S. J. M. Auld, O. B. E., represents the Institution of Petroleum Technologists on the Grand Council of the congress. J. Kewlet, W. H. Cadman and Dr. F. H. Garner are members of the technical committee.

Conventions

S. A. E. The Society of Automotive Engineers will meet at Cleveland, Ohio, September 18-19.

N. P. A. The National Petroleum Association, September 18-20, will hold its annual meeting at Atlantic City.

A. G. A. The American Gas Association, Manufacturers Division, will meet at Atlantic City, October 14 to 18.

N. S. C. National Safety Council holds the twenty-fourth annual Safety Congress, in Louisville, Kentucky, October 14-18.

I. P. A. Independent Petroleum Association will hold its 6th annual meeting at Dallas, Texas, November 4 and 5.

A. P. I. The American Petroleum Institute will hold its 16th annual meeting at the Biltmore Hotel, Los Angeles, November 11-14.

C. N. G. A. The California Natural Gasoline Association holds its meeting the first Thursday of every month in the Richfield Building, Los Angeles, California.

Louisiana-Arkansas Refiners Association, Technical Division holds monthly technical group meetings the second Friday of each month at announced meeting place.

Three New A. P. I. Directors Named

DIRECTORS of the American Petroleum Institute have elected three men to membership to fill vacancies caused by deaths and resignation. W. H. Berg, vice president of Standard Oil Company of California, San Francisco, was elected director in the production group, with term expiring in 1936. He succeeds Oscar Sutro, of the same company, deceased. Torkild Rieber, vice president of The Texas Company, New York, was elected director in the at-large group to succeed C. B. Ames, of the same company, deceased. His term also expires in 1936.

The resignation of Ralph Zook, of Sloan & Zook Company, Bradford, Pa., as director in the at-large group was accepted. The board elected as his successor T. P. Thompson, Jr., also of Bradford, president of Pennsylvania Grade Crude Oil Association. His term expires in 1935.

Resolutions in memoriam recording with sorrow the deaths of Directors Ames and Sutro were passed.

Committees to Arrange A.P.I. Meeting in California

C. S. JONES, executive vice president of Rio Grande Oil Company, Los Angeles, has been appointed general chairman of the committee organization making local arrangements for the sixteenth annual meeting of the American Petroleum Institute in Los Angeles November 11 to 14.

Other committee chairmen include: Finance, R. D. Matthews, Union Oil

Lacy Walker, secretary of the American Petroleum Institute, and Mrs. Walker, of New York, posed for this picture in the Los Angeles Biltmore where they are spending a few days while he is making preliminary plans for the Institute meeting there November 11-14. A feature of the entertainment is that wives and children of oil men will have a part in the program.

—International News Photo

Company of California; reception, W. C. McDuffie, Richfield Oil Company of California; hotel reservations, C. E. Olmsted, The Texas Company (California); banquet, W. L. Stewart, Jr., Union Oil Company of California; transportation, J. U. Stair, Shell Oil Company; publicity, H. E. Britzman, Rio Grande Oil Company; golf, J. A. Jones, Associated Oil Company; at large, W. L. McLaine, General Petroleum Corporation of California; and wildcats, J. A. Dunn, National Supply Company of California. Entertainment will be in charge of the Wildcats, a social organization.

Included among the committees is a general committee of 100 prominent oil and supply company executives representing all phases of the industry. An advisory committee also has been appointed, with R. E. Collom, of Continental Oil Company as chairman. Members are:

Lionel Barneson, Bankline Oil Company; S. Belither, Shell Oil Company; A. C. Dieriex, Honolulu Oil Corporation; D. S. Faulkner, National Supply Company of California; E. B. Gilmore, Gilmore Oil Company; P. M. Gregg, Union Oil Company of California; S. A. Guiberson, Jr.; Oscar R. Howard; W. F. Humphrey, Associated Oil Company, and K. R. Kingsbury, Standard Oil Company of California.

L. H. Keim, Oil Well Supply Company; W. H. Morgan, R. R. Bush Oil Company; W. C. McDuffie, Richfield Oil Company of California; A. B. Macbeth, Southern California Gas Company; A. C. Mattei, Honolulu Oil Corporation; S. B. Mosher, Signal Oil & Gas Company; T. A. O'Donnell, and P. H. O'Neil.

William Reinhardt, Kettleman North Dome Association; F. C. Ripley, Chanslor-Canfield Midway Oil Company; C. C. Stanley, The Texas Company; W. L. Valentine, Fullerton Oil Company, and H. L. Westbrook, Belridge Oil Company.

Members of the executive committee are:

General Chairman Jones; R. A. Broomfield, Barnsdall Oil Company; J. A. Crawford, Republic Supply Company of California; Ralph B. Lloyd, The Lloyd Corporation; C. E. Olmsted, The Texas Company (California); L. P. St. Clair Union Oil Company of California; and A. L. Weil, General Petroleum Corporation of California.

DURIRON

MIXING NOZZLE

That's All ~ That's Enough

So simple to install . . . just slipped in between pipe flanges like a gasket. No moving parts. Corrosion and erosion resistant through and through. Does away with baffle plates in your treating column.

THE DURIRON COMPANY, Inc.

Specialists in the Manufacture of Corrosion-Resistant Products

412 N. FINDLAY ST. DAYTON, OHIO

Bureau of Mines Opens Station at Laramie

THE petroleum field office of the Bureau of Mines, Department of the Interior, at Laramie, Wyoming, is being reopened as a result of a provision in the department's appropriation for the fiscal year ending June 30, 1936, for establishing and operating a petroleum experiment station on the campus of the University of Wyoming. Offices and laboratories for the staff, composed of petroleum engineers and chemists, are now in temporary quarters but will be moved to a new building to be erected by the university.

Pending erection and equipping of the building, the staff will make a general survey of the Rocky Mountain oil fields and refineries to obtain data concerning the problems involved in the development and operation of the fields and in the refining and utilization of the oil produced in the Rocky Mountain area. Following this general survey, specific problems in petroleum engineering and in refining will be studied. A principal objective will be to obtain data helpful in the refining and use of the Rocky Mountain black oils, which are an important factor in the petroleum industry in that area.

The studies at Laramie will be correlated with the unified program of research in the Petroleum and Natural Gas Division of the Bureau of Mines carried on at the Petroleum Experiment Station at Bartlesville, Oklahoma, and petroleum field offices at Dallas and Amarillo, Texas, and San Francisco, California.

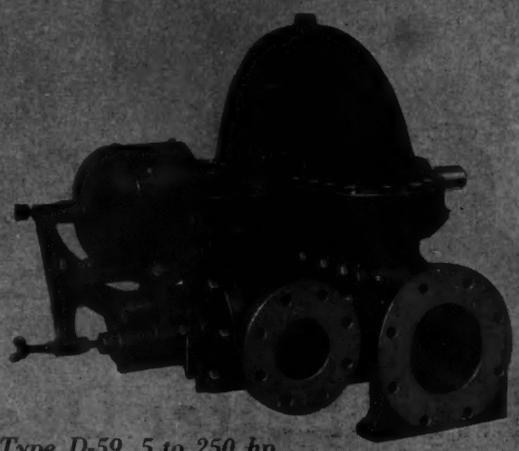
For the present, the Bureau's petroleum refining studies will be made at Bartlesville and Laramie, and the work of the two stations will be planned with the objective of obtaining fundamental data that are lacking and for which a need exists.

The Bureau's technical work on petroleum including the studies at Laramie is under the general supervision of R. A. Cattell, Chief Engineer, Petroleum and Natural Gas Division, Bureau of Mines, headquartered in Washington, D. C. Harold P. Rue, Harold M. Thorne and Ralph H. Espach have been transferred from the Bartlesville petroleum experiment station to the Laramie office.

Save Money with G-E Mechanical Drive Steam Turbines

THESE SINGLE-STAGE G-E TURBINES COMBINE CONTINUOUS AND LOW-COST SERVICE

Type D-57, 5 to 125 hp.



Type D-59, 5 to 250 hp.

Type D-58, 40 to 400 hp.

720-234H

BECAUSE—

OVER-ALL ECONOMY IS HIGH

The low-pressure exhaust steam is particularly suitable for heating or processing — it is *clean* steam, free from oil. A clean heating system saves fuel.

MAINTENANCE IS LOW

All parts used in these turbines are built to endure years of wear under the toughest operating conditions. The cost of replacements or repairs is negligible.

INSTALLATION COSTS ARE LOW

These turbines are compact, which simplifies mounting; the smooth operation permits the use of inexpensive foundations; and the piping is simple.

There is a complete line of G-E turbines, in every size and rating. Perhaps you do not have literature fully describing General Electric turbines. If not, the nearest G-E sales office can supply you with it. General Electric Company, Schenectady, N. Y.

For Driving

- PUMPS
- FANS
- COMPRESSORS
- BLOWERS
- LINE SHAFTS
- PULVERIZERS

GENERAL ELECTRIC

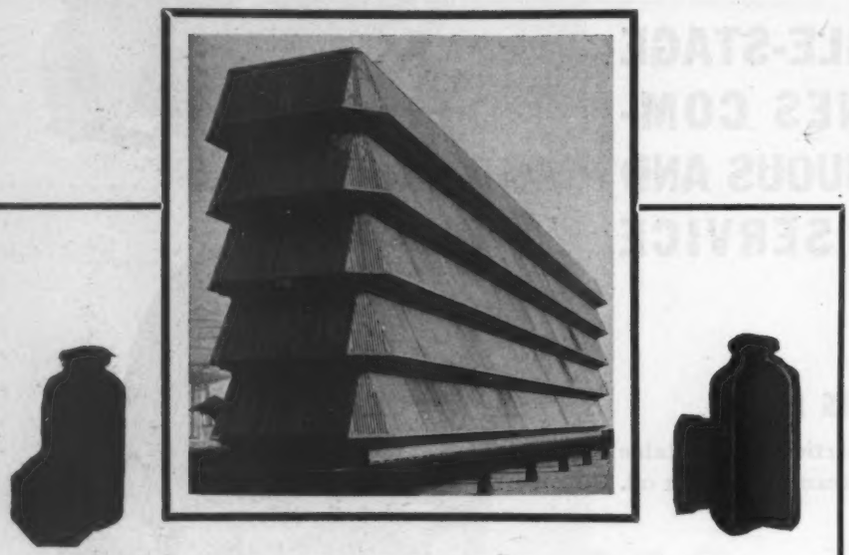
Chemical Industries Exposition Plans

RECOGNITION of the value of display by American business is indicated by the enthusiastic planning now under way for the Fifteenth Exposition of Chemical Industries. The industrial promotion value of expositions as a supplement to trade journal and newspaper advertising is becoming more and more appreciated both by exhibitors and their public. One evidence of this is the number of companies responding to the opportunity to exhibit their products and equipment at the Exposition of Chemical Industries to be held in New York, at the Grand Central Palace, December 2-7, 1935.

A high standard of display was attained at the last chemical exposition held in 1933. Results to which this excellence contributed were a large increase in attendance and remarkable sales results to the exhibitors. The experienced exhibitor has in mind the viewpoint of the visitor and arranges graphic and dynamic displays which are comprehensive, but clear. The experienced exhibitor considers how most effectively to convey to the visitor what his product is, what it will do, and where. Design, color, animation, and clear-message simplicity are high points in making an exhibitor's booth interesting and effective.

At the exposition the customer's interest is aroused through seeing the product displayed effectively. There are experts to tell him just how the product is used. From the wide variety of products concentrated in one place he may easily judge which is best suited to his needs, and when he has done this, sales engineers are readily available to give advice and estimates on his requirements. The exposition corroborates in terms of materials and machines the claims which have been advanced through trade journal and newspaper articles and advertising.

The displays at past chemical expositions have given the exposition a positive personality. They have become an awaited inspiration to visitors attending and have proved an excellent market place for companies exhibiting. Accordingly with increased interest in display, a yet greater success is anticipated at the exposition in December, 1935. The conduct of the exposition and all details of exhibit arrangement and leasing are in charge of the International Exposition Company, Grand Central Palace, New York, and will as heretofore be under the personal direction of Charles F. Roth, manager.



Their Better Design

Means Better Performance and Greater Cooling Economy

MARLEY patented spray nozzles that provide better water break-up and distribution! The Marley patented louvred louvre that improves air circulation and practically eliminates drift loss! Marley deck design that secures equal water distribution to all decks and complete stoppage of all water at every deck.
These and other outstanding advantages of design make Marley deck type cooling towers more simple, more efficient, more economical. Write for full details.

THE MARLEY COMPANY » 1915 Walnut, Kansas City, Mo.

MARLEY

Spray Deck Type

COOLING TOWERS

Polymerization Process Corporation Formed

FRANK PHILLIPS, president of Phillips Petroleum Company, announces that his company has organized a new corporation, known as The Polymerization Process Corporation, through which patent licenses will be available to the petroleum and natural gas industries for the practice of the polymerization process for making premium grade gasoline from refinery and natural gases.

Through exchange of patents, The Texas Corporation, Standard Oil Company (Indiana), and Standard Oil Company (New Jersey) have an interest in the new corporation and will use the new process.

The M. W. Kellogg Company has been appointed licensing agent and is preparing to make estimates and bids on complete plants for carrying out the polymerization process.

Phillips Petroleum Company for many years has been a large producer of natural gas and liquefied products derived from it, such as natural gas, gasoline and liquefied gas, but the new polymerization process is radically different in that a chemical change takes place instead of merely a physical separation.

Phillips Petroleum Company developed and has been operating the new process on a full commercial scale. Complete operating data will be available to the licensing agent of the new company.

T. B. Hudson, Phillips Petroleum Company, is president of the new corporation.

FRED VAN COVERN has resumed his duties as director of the Department of Statistics of the American Petroleum Institute, and again is occupying his office in the Institute's headquarters at New York. For some time he has been in Washington, where he directed the staff of statistical Sub-Committee "A" of the Planning and Coordination Committee. He was also assistant treasurer of the committee. Joseph Buder, who accompanied Van Covern to Washington as assistant, returned with him to the staff of the Institute's Department of Statistics.

RUSSELL M. LILLY

RUSSELL M. LILLY, experiment chemist, Sinclair Refining Company, Fort Worth, Texas, has resigned his position to become associated with J. C. Maxwell and associates, of Fort Worth. For the present his position with this organization will be that of assistant to the superintendent of drilling and production in the Kermit area of Winkler County, Texas. Following graduation Lilly taught school for two years and entered the petroleum industry as a chemist and relief operating engineer in refrigeration work. Following this he was with M. F. Powers Company, manufacturers of natural gasoline for several years. Later he was with Texas Pacific Coal & Oil Company, Fort Worth, as control chemist. Leaving this position he became an operator on the debutanizer-stabilizer unit for Sinclair Refining Company at Fort Worth. After a few months of this work he was transferred to the laboratory force as experimental chemist, working under the direction of L. P. Foster, Sinclair Development Company, doing research work in chemical refining of gasolines and kerosenes produced from sour crude during the past two years. He has contributed several articles to THE REFINER during the past year or so.

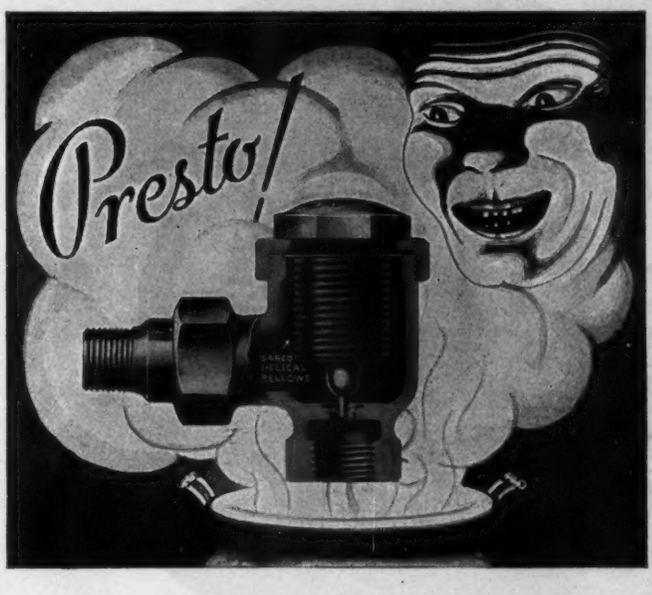
COL. GEORGE A. BURRELL of Burrell-Mase Engineering Company, Pittsburgh and Tulsa, has received the Lamme Medal from Ohio State University for outstanding achievement in engineering. He is a graduate chemical engineer from Ohio State and received the degree of Doctor of Science from Wesleyan University. During the World War he was in charge of research and development work for the army and navy. He located the helium supply in Texas for the government in 1917 and initiated the government's helium program. The Army gave him the distinguished service medal. During 1929-31 he was in Russia aiding the soviet government in modernization of its gasoline and natural gas industries. His company has erected many gasoline plants, pressure distillate stabilizers, liquid gas plants, vapor recovery plants and similar processes for the petroleum refining and natural gasoline industry.

FRANK B. BURNS has left the research staff of Barber Asphalt Company's plant at Maurer, N. J., to work as research chemist in the building materials research laboratories of United States Gypsum Company, Chicago, where he will do research and development work on asphalt products.

HAROLD L. GERHART, who received his Ph.D. from Northwestern University in June, is now research chemist with Standard Oil Company (Indiana), Whiting, Indiana.

R. J. DEARBORN, patent counsel of The Texas Company, has resigned from the presidencies of the Process Management Corporation and Gasoline Products Company and has become chairman of the board of these companies. William F. Moore, for some years vice president and general manager, was elected president of the two companies.

DR. ARTHUR DEHON LITTLE, 71, chairman of the board and founder of Arthur D. Little, Inc., a past president of the American Chemical Society, and a member of the advisory board of Industrial & Engineering Chemistry, died suddenly August 1, 1935, at Northeast Harbor, Maine, where he had gone to spend the summer with Mrs. Little. On arrival



NEW Radiator Traps from OLD
with
SARCO Replacement Units

Sarco Adapters give new life to old radiator traps of any make. They make radiators heat rapidly and evenly so that ample heat will be furnished with greatly reduced steam pressure.

Old radiator or drip traps equipped with Sarco Adapters are guaranteed equal to new in steam saving efficiency.

Sarco Adapters consist of a cap and a motor element. The cost is low, as you can use the old bodies and do not have to disturb pipe connections.

Now is the time to modernize—a Sarco Adapter to fit every trap body and a Sarco Packless Valve Bonnet for all makes of Inlet Valves.

Tell us the make of the heating system and we will send full information. Ask for Catalog S-111.

SARCO CO., Inc.
183 Madison Ave., NewYork, N.Y.
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Also makers of Sarco Steam Traps, Temperature Regulators, Radiator Traps, Packless Inlet Valves, Combination Float and Thermostatic Traps, Return Traps, Air Eliminators, and Strainers.

at the hotel on July 28, Dr. Little seemed completely exhausted as the result of a cold. The following day pneumonia developed. He was born in Boston, Massachusetts, December 15, 1863. He was a member of the class of 1885 of Massachusetts Institute of Technology. His works are well known throughout the scientific world for during his life he contributed much to technical development and progress in many industries.

D. F. JURGENSEN, formerly research chemist with The Pure Oil Company, has resigned to join the research staff of United States Gypsum Company, Chicago.

▼ PLANT ACTIVITIES ▼

Cracking: Danciger Refining Company's Longview, Texas refinery, is again mentioned in reports as planning early construction of a modern cracking unit. The company has completed extensive revamping work at Pampa, Texas.

Enlarge: Shoreline Refining Company, Lewis, (Vivian) Louisiana, is enlarging through replacement of fractionating columns, additional condensers. A modern canning plant is being installed to handle quart and five-quart sizes.

Improvements: Stone Oil Company, Texas City, has completed improvements involving erection of a new tube still for viscosity breaking service.

Construction: Refinery Export Corporation, Texas City, Texas, which purchased the old Pierce refinery, has completed its terminal facilities and is handling oils. Under direction of R. X. Cook, the company is building a skimming plant using chiefly materials at hand and available from the old plant. Reports of plans for a cracking unit at this plant have not been confirmed.

Solvent Plant: Gulf Refining Company, Port Arthur, Texas, plans beginning operation of its new 5000-barrel Furfural refining process about October 1. Texaco Development Corporation licensors.

Enlarge: Mid-West Refining Company, Alma, Michigan, is doubling capacity through erection of a new topping unit, at a cost of about $50,000. Contract to Leader Industries, Inc.

Gasoline Plant: Royalite Oil Company, in the South Turner Valley field, Alberta, Canada, has completed its new absorption natural gasoline plant and placed it in operation. Capacity is reported at 60,000,000 cubic feet daily.

Refinery: Carson Refining Company, Carson City, Michigan, headed by Del Fortney, president, plans erection of 1000-barrel skimming plant under supervision of E. G. Guy, consultant, who was named vice president. Capitalization $65,000.

Repairs: Old Dutch Refining Company, Muskegon, Michigan, has completed re-installation of its $10,000 continuous chemical treating plant recently destroyed by fire.

Purchase: Master Petroleum Company, Waco, Texas, has purchased from Phoenix Refining Company its refinery just west of Dallas, which Phoenix purchased from Oriental Oil Company several months ago.

Refinery: Mid-Petroleum Marketing Company, Inc., Oklahoma City, Oklahoma, last month erected a 250-barrel skimming plant on the Rock Island railroad in southeastern Wheeler County, Texas Panhandle, in the Osborn-Woodley pool, only oil area of consequence in the Panhandle without pipe line connections.

Improvements: Atlantic Refining Company, Philadelphia, in its semi-annual report states that the company made capital expenditures for fixed assets in the refining department during first six months of 1935 totalling $571,000. Completion of Keystone Pipe Line Company extension of gasoline lines will result in discontinuance of operations at the high-cost Pittsburgh refinery, and reduction of operations at the Franklin, Pennsylvania refinery, probably before the close of the year.

Improvements: Skelly Oil Company, El Dorado, Kansas, has completed revamping the crude stills, modernizing furnace and still equipment, rebuilding the condenser system and adding two fractionators.

Gasoline Plant: Gilliland Refining Company, Gladewater, Texas, is reported planning erection of a gasoline

SOLVAY

TRADE MARK REG. U. S. PAT. OFF.

PRODUCTS

58% Soda Ash
Caustic Soda

Solid—Flake—Ground—Liquid

Leading refiners depend on these products for the quality and uniformity which industry inevitably associates with the name Solvay. First in pioneering the development of American sources of alkali, The Solvay Process Company is recognized as the outstanding leader of its field—first in size and first in facilities for rendering efficient service.

Stragetically located distributing points ensure prompt delivery of Solvay products with minimum transportation charges.

Write today for prices and full information.

Solvay Sales Corporation

Alkalies and Chemical Products Manufactured by The Solvay Process Company

40 Rector St. New York

plant on a 15-acre plant site under lease by Tide Water Oil Company in the W. W. Simms survey, Jernigan Farm, Gregg County. Plant and gathering lines are reported cost of $400,000.

Refinery: Wolverine Petroleum Products Company, W. S. Behrens, president, Alma, Michigan, is reported planning construction of a 1000-barrel skimming plant at Alma.

Refinery: Borim Brothers, Detroit, Michigan, has announced completion of plans for construction of a 2000-barrel skimming plant at Alma, Michigan, stating property has been secured and work will start immediately.

Refinery: Valley Port Refining Company, G. L. Rowsey, president, Port Isabel (Brownsville) Texas, is erecting a 5000-barrel refinery. Contract to Wyatt Metal & Boiler Works, Houston. Reported cost $250,000.

Cracking: Wadhams Oil Company, East Chicago, has awarded contract to M. W. Kellogg Company for construction of a combination skimming and cracking unit. Reported cost $200,000.

Refinery: Stockton Oil Company, 405 Montgomery Street, San Francisco, is reported constructing an oil refinery on Rough and Ready Island, Stockton. Estimated cost $75,000.

Refinery: American Petrol-Chemical Company, a $150,000 corporation, Wayne, Michigan, headed by Arthur S. Hinch, has announced plans for a 500-barrel skimming plant to start building at once.

Cracking: Cascade Refining Company, formerly Model Refining Company, Kilgore, Texas, now owned by the Potter Brothers, has completed erection of a cracking unit.

Gasoline Plant: Sinclair Refining Company, Tulsa, is installing a natural gasoline plant in the Joiner section of the East Texas field. Options have been taken on right-of-way for about 200 miles of gathering system necessary to link the various properties operated by Sinclair Prairie Oil Company in the south portion of the field. The plant will be near Wright City, Smith County, and will have a greater capacity than the company's operating plant in the Longview, or north portion of the field. The latter is rated at 30,000 gallons daily.

Refinery: Mid-Petroleum Marketing Company, Inc., 550 First National Bank Building, Oklahoma City, has placed in operation a 250-barrel crude skimming plant in the southeast portion of Wheeler County, Texas Panhandle. The plant is adjacent to the only important oil production in the Panhandle that is isolated from pipe line connections.

Cracking Unit: Malco Refineries, Inc., Artesia, New Mexico, have signed contract with Ralph M. Parsons Company, for construction of a $150,000 Dubbs cracking unit. The new plant will have capacity of 700 barrels per day and will convert 57 percent to high octane gasoline. The plant consists now of a Southwestern skimming unit with capacity of 2000 barrels, which was installed in 1931. Lloyd Simon is general superintendent. M. E. Baish heads the company.

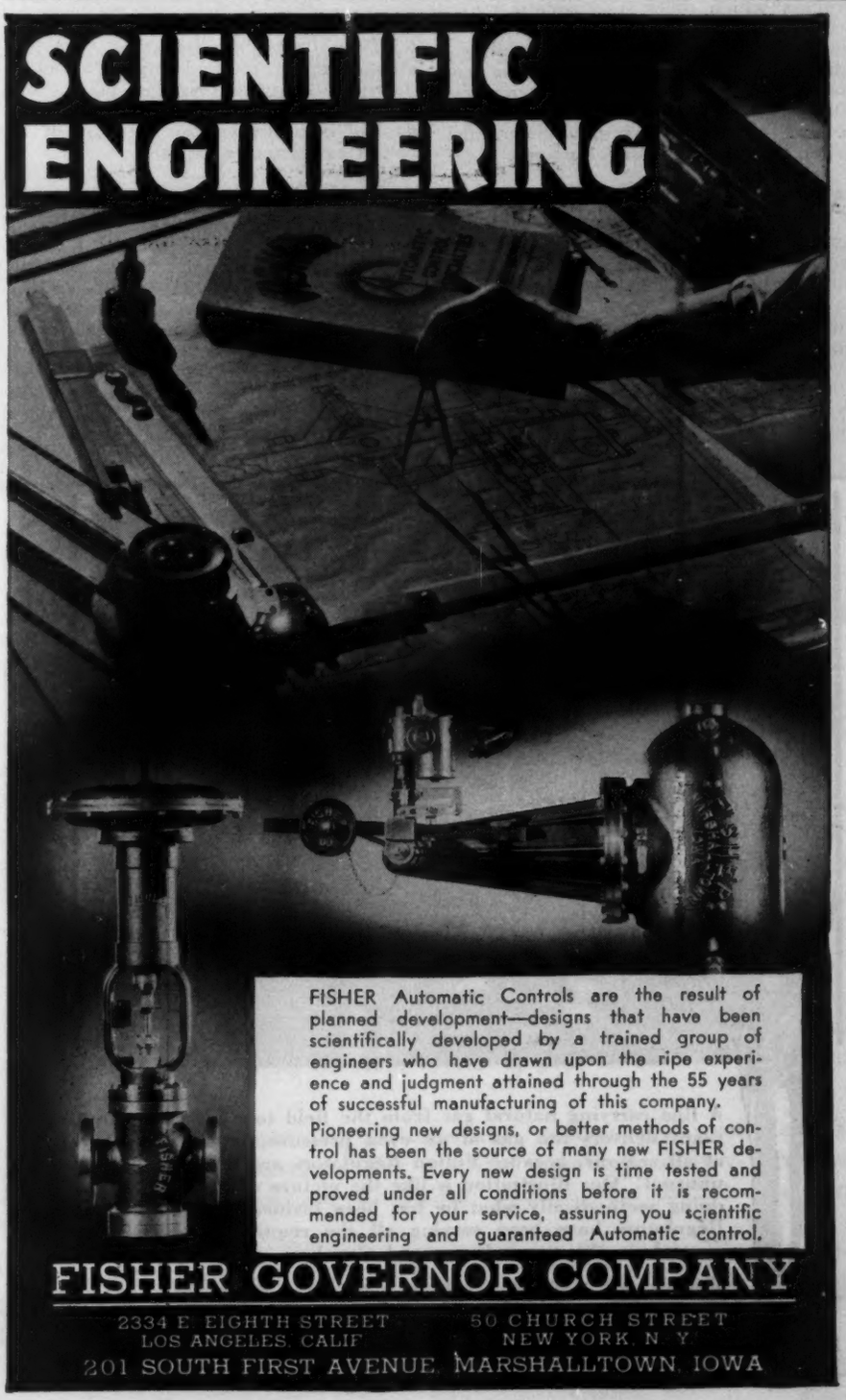
▼ BUSINESS NOTES ▼

A. M. BYERS COMPANY, Pittsburgh, Pa., wrought iron manufacturers since 1864, has announced the third major expansion project for this company in recent years.

Several years ago the company completed a large and modern wrought iron mill at Ambridge, Pennsylvania, for manufacturing genuine wrought iron under its new process. Following this, the operations were further expanded to include the re-introduction of a wide range of wrought iron products which includes plates, sheets, merchant bars, angles, structurals, and forging billets.

The third step in broadening the sales and manufacturing activities of the company was taken when J. Frederic Byers, chairman of the board, announced that Byers steel pipe would be manufactured in addition to the present complete line of wrought iron products. Byers steel pipe will be made in the company's modern pipe mills under the same supervision as exists on wrought iron pipe.

"The use of wrought iron pipe," says Mr. Byers, "for corrosive services in buildings, industrial plants, and underground lines, with steel pipe for practically all other piping requirements,


SCIENTIFIC
ENGINEERING
FISHER Automatic Controls are the result of planned development—designs that have been scientifically developed by a trained group of engineers who have drawn upon the ripe experience and judgment attained through the 55 years of successful manufacturing of this company.
Pioneering new designs, or better methods of control has been the source of many new FISHER developments. Every new design is time tested and proved under all conditions before it is recommended for your service, assuring you scientific engineering and guaranteed Automatic control.
FISHER GOVERNOR COMPANY
2334 E. EIGHTH STREET
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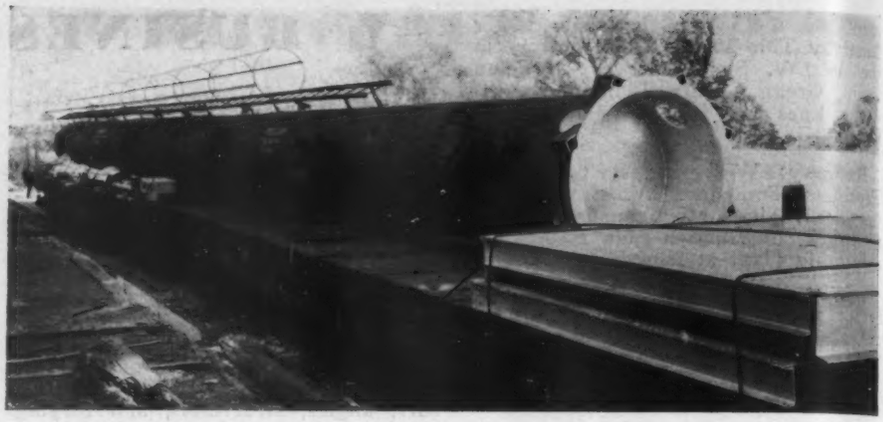
50 CHURCH STREET
NEW YORK, N. Y.
201 SOUTH FIRST AVENUE, MARSHALLTOWN, IOWA

materially broadens our markets. Our customers who buy steel pipe as well as wrought iron have suggested that we make a steel pipe. This development means that we can now offer our customers both steel and wrought iron pipe, thereby meeting practically all of their pipe requirements."

ACTICARBONE CORPORATION, owners of the Acticarbone process for the recovery of gasoline from natural gas, now is located at 25 Broadway, New York. The process, it is reported, has found favor in European countries and now is being introduced in America. Its principal claims are high efficiency and economy resulting from improvements in design and operating technique. The company has prepared technical literature regarding the process which discloses operating figures and data concerning European installations of various capacity ratings. The process is being introduced in this country after 13 years of scientific study and progress, during which time several technical papers have been published regarding the development.

A 1000-BARREL topping unit, built in four weeks, shipped complete on three flat cars, and erected in two weeks, is one of the latest developments of Vulcan Steel Tank Corporation which designed and furnished the equipment for Pettus Refining Company at Mathis, Texas. Ninety percent overhead and side cuts will be produced single flash from a 74-foot fractionator. A pipe still with steel-cased combustion space, with insulated walls lined with light weight, insulating firebrick, all shop-fabricated and shipped knocked down with refractories in place, will heat the crude which has been partially flashed in a devaporizer interposed between exchanger and still.



One thousand-barrel portable topping unit shipped complete by Vulcan Steel Tank Corporation

HENRY VOGT MACHINE COMPANY, Louisville, Ky., announces the following additions to its sales personnel: G. B. Mattingley, formerly with Edge Moor Iron Company, is in the boiler sales division of the Philadelphia office, in the Commercial Trust Building; J. C. Mahoney, formerly with C. H. Leach Company and Alco Products, Inc., is in the heat exchanger division at the company's New York office at 80 Broad Street.

J. P. DEVINE MANUFACTURING COMPANY, announces the election of the following officers: C. W. Reynolds, president and member of board of directors; J. A. Guyer, executive vice president and member of board of directors; W. A. Jackson, secretary and treasurer, and H. H. Cust, assistant secretary and assistant treasurer, and member of board of directors. H. R. Campbell was appointed vice president, and will devote his time to the sale of dri-ice plants.

J. H. BROWN, formerly Eastern sales manager of Sullivan Machinery Company, has joined Worthington Pump and Machinery Corporation as regional manager of its mining and construction division, covering the mid-western territory, with headquarters in Chicago.

Brown is a graduate of Massachusetts Institute of Technology, class of 1905. During the N.R.A. period he served as a member of the code authority of the Compressed Air Institute. Widely known in construction and mining circles, he brings to Worthington a long experience in the manufacture and sale of equipment for these fields.

THE Kennedy Valve Manufacturing Company announces appointment of O. R. Lane as its representative in Oklahoma, Arkansas, Tennessee, eastern Missouri, and southern Illinois and Indiana, with headquarters at 455 Paul Brown Building, St. Louis.

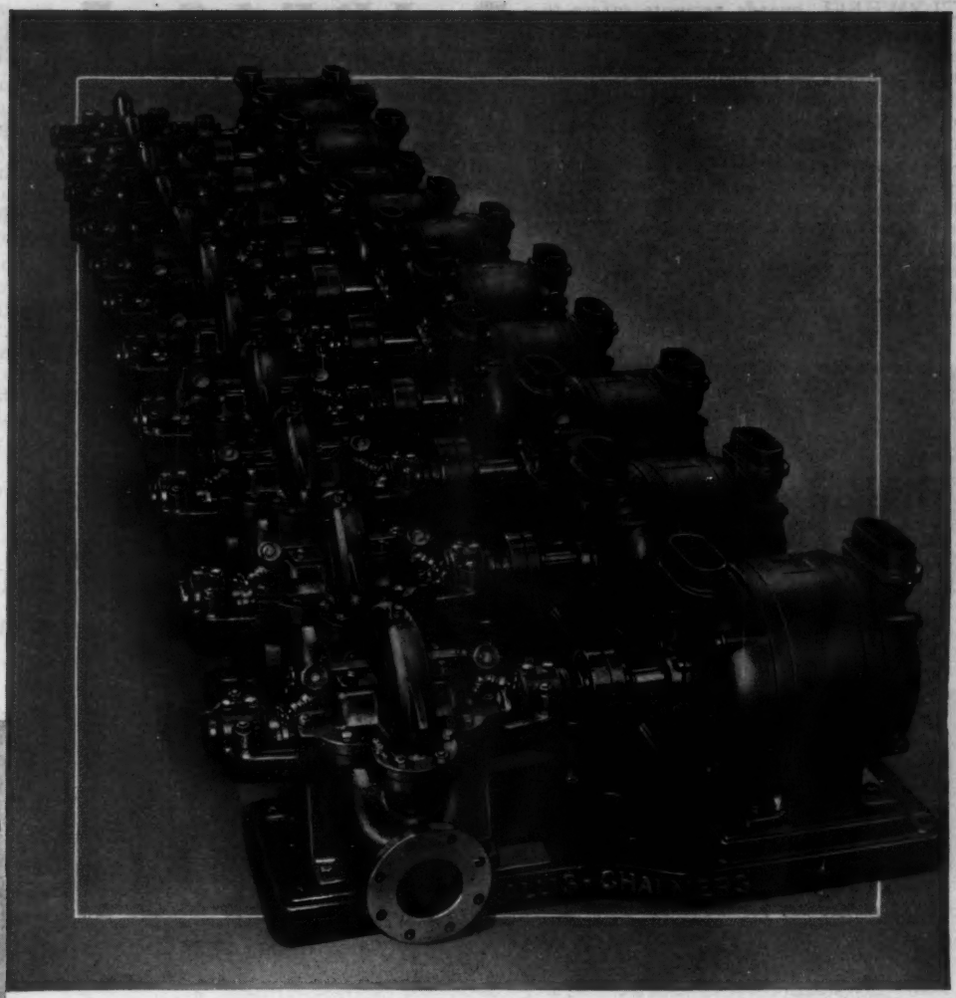
OPENING of a new sales office at 622 Dwight Building, Kansas City, Mo., effective September 1, is announced by N. J. Clarke, vice president in charge of sales, Republic Steel Corporation, Youngstown, Ohio. The new office will be in charge of Robert L. Pierce of the St. Louis district sales office.

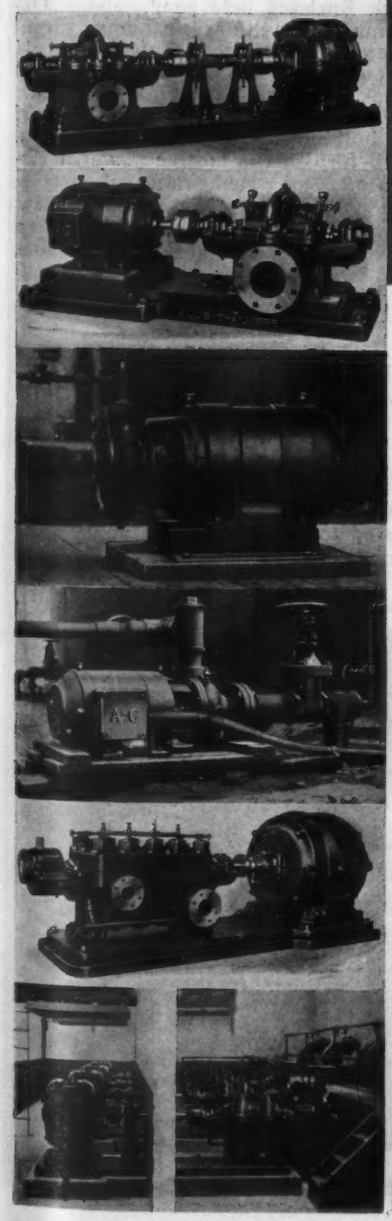
SOLVAY SALES CORPORATION has announced opening of its new southwestern branch at 503 Petroleum Building, Houston, Texas. There is no change contemplated in the present distributing representation. The company markets production of alkalies and chemical products manufactured by The Solvay Process Company, with plants at Syracuse, New York, Detroit, Michigan, and Baton Rouge, Louisiana.

A line carrying natural gas from the field to a large oil-company plant delivers the gas at an even pressure, in all weathers and at all seasons, because Fulton Regulators are on guard. Nothing unusual! Our illustration is like the picture of a sentry on guard, doing methodically what he has been trained to do well. Fulton Regulators have been serving all the requirements of pressure control, in the gas industry and elsewhere, for fifty years.

The Chaplin-Fulton Manufacturing Co.

28-40 Penn Avenue **Pittsburgh, Pa.**





Good Pumps . . .
for Refinery Service

ALLIS-CHALMERS builds three principal types of high efficiency pumps for refinery service. Type S, double-suction, single-stage pumps shown above and in the first two illustrations at the left, are used for pumping cooling water to condensers, handling light oils, gasoline, kerosene and similar liquids.

Type SSU pumps, as shown in the third and fourth illustrations at the left, are built for 30 to 800 gallon per minute capacities. Some sizes will pump against heads up to 350 feet. They have been used for loading service, treating plants, sumps, and some light oil transfer.

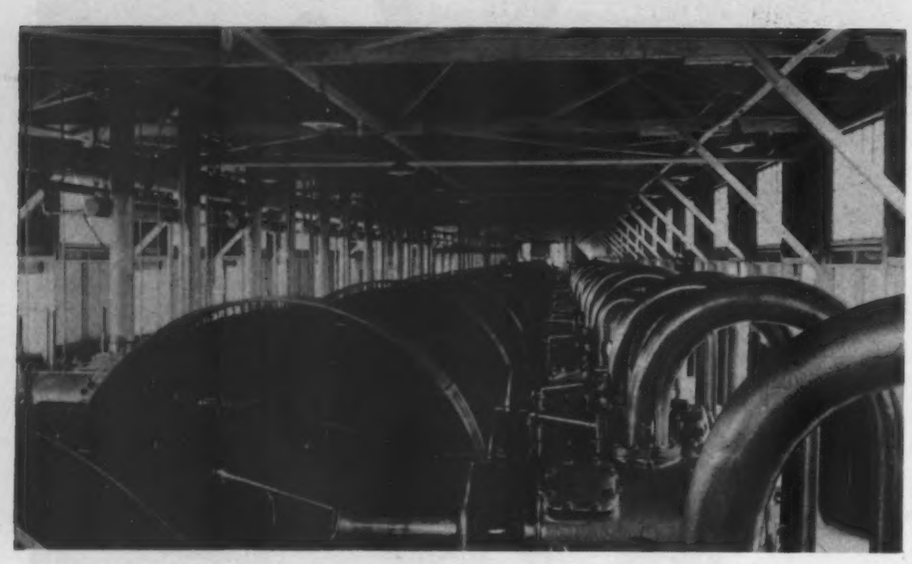
Type M double-suction, multi-stage pumps are used for the higher head applications, for loading gasoline, as low-temperature moderate-pressure charging pumps, for boiler-feed and similar service.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

FLYWHEEL guards promote safety to a large extent when oilers and engineers need to climb over bed plates when the machinery is in motion. A gasoline plant located in Santa Fe Springs, California, has all of the flywheels guarded to prevent danger to operators.

Long sheets of heavy rolled steel are used for the pieces covering the face of the flywheels, attached to the bed plate "distance" pieces before and behind the flywheels. Sliding doors are fitted to these covers, which may be moved upward when an engine is to be jacked over into position for starting.



Sliding Doors are fitted to fly wheel guards so that guards need not be removed for starting

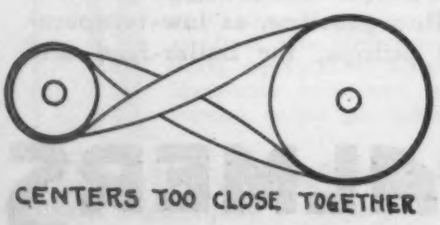
Heavy, closely woven mesh netting is used for the side guards which are securely fastened by welding to the flywheel face guard plate. The assembly is removable, being bolted to the points on the spacers so they can be taken away when it is necessary to repair, or adjust anything covered by the guards. The cost of guards similar to these will vary as to the accessibility of the material.

J.C.A.

Rule for Crossed Belt Drives

A NEW rule for crossed belt drives superior to the old ones which do not take all factors into consideration is presented. This rule applies to high grade, two-ply leather belting:

Rule: Add the diameter of the pulleys in inches, multiply by two, and then multiply by the cube root of the width of the belt in inches. The result is the minimum distance between shaft centers in inches.



CENTERS TOO CLOSE TOGETHER

▼ IDEAS ▼

This rule is limited up to eight-inch belts and pulleys up to 40 inches in diameter. A center distance of 25 feet will take care of any ordinary combination within these limits, hence 25 feet need not be exceeded.

Example: Diameter of driving pulley, 12-inch; diameter of follower pulley, 10-inch; width of belt, three inches. What is the minimum distance between pulley centers?

The answer, applying the above rule, is 64 inches.

Example No. 2: Diameter of driving pulley 40 inches; diameter of follower pulley, 40 inches; width of belt, eight inches. What is the minimum distance between pulley centers?

Answer—Applying the above rule we get an amount greater than the safe distance 25 feet mentioned above. The center distance may be made greater than 25 feet if desired, but it should not be less.

For single-ply belts that are well made, use the same rule as above. Single-ply belts are more erratic on crossed drives than are two-ply, owing to the uneven stretch that so commonly occurs. Always use two-ply high grade belts on drives of this type wherever practicable.

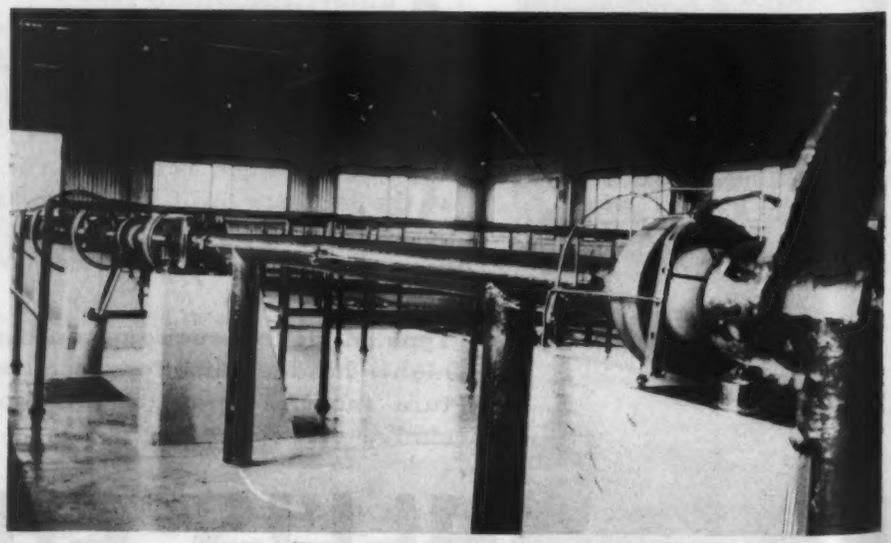
Sometimes shafts of crossed belt drives are as close together as two times the sum of the two pulley diameters. For belts one inch wide that distance is all right, but for belts wider than one inch it is close. The twist is then too abrupt and there will be considerable rubbing and wear at the crossing point.

W. F. SCHAPHORST, M. E.,
Newark, New Jersey.

Safety Guard for Line Shaft

WHEN Skelly Oil Company built its new gasoline plant in the South Burbank field near Fairfax, Oklahoma, the auxiliary room was constructed so that a line shaft drive could be employed to operate centrifugal pumps handling plant cooling water. The line shaft runs the full length of the building, with the gas engines, which furnish the motive power, located in one end. Removable pipe guards were placed where the driving pulleys were located on the shaft, but instead of being slipped in sockets, each riser was fitted with a salvaged ground-joint lip-union. This method makes a more rigid guard, and yet the assembly may be removed if desired.

That part of the line shaft not protected by pipe guards is covered with pipe. Standards are set in the concrete floor as a permanent installation, with a four-inch pipe across the upper ends. This pipe was split and welded to the risers, but the upper half was secured to the lower by bolting, using welded lugs. The line shaft couplings not protected by the pipe guard rails



Line Shaft Safety Guard

SULPHURIC ACID—Make your own in a CHEMICO SLUDGE CONVERSION PLANT and eliminate all refinery acid problems . . . .

THE FRESH ACID obtained at low cost from the decomposition of acid sludge in a Chemico Sludge Conversion Plant is *worth more* than an equivalent amount of purchased acid. Not only is the refinery made independent of outside acid supply, but the sludge residue, otherwise a troublesome waste product involving handling expense and serious disposal questions, is converted into pulverized coke of substantial fuel value, the utilization of which gives an additional profit. As no objectionable fumes escape to the atmosphere, and no useless residue remains, waste disposal, with its accompanying risk of controversy with public authorities, is wholly eliminated.

How the Chemico Sludge Conversion Plant operates

A CHEMICO Sludge Conversion Plant produces clean clear acid, direct from raw unseparated acid sludge, and can also be designed to provide the make-up acid to compensate for treating losses. The acid produced may be 98% H_2SO_4 or of any desired higher strength, regardless of the initial strength of the sludge. The output of the plant requires no further purification or concentration.

The process is simple. The raw sludge is decomposed by heat to strong sulphur-dioxide gas and a dry granular coke. The gas is scrubbed clean of impurities (with recovery of the oil content) and converted into sulphuric acid in a contact acid production unit employing long-lived vanadium catalyst. Operation is continuous and the equipment is sealed throughout to prevent escape of fumes. The make-up acid may be produced from sulphur or hydrogen-sulphide recovered from still gases. *Sludges that cannot be separated or utilized profitably by former processes may be satisfactorily converted into strong acid by this Chemico Conversion Process.*

Other types of Chemico plants, including pressure separators, sludge acid concentrators, contact acid production equipment, etc., are available to meet special requirements or for improving capacity and economy in remodeling.

The capital investment, operating costs, economies and net annual return from a Chemico Sludge Conversion Plant can be determined in advance and in definite figures. If your acid requirement amounts to 20 tons or more per day, an installation would develop substantial profit *in tangibles alone,* to say nothing of the often more important complete relief from disposal expense and hazards.

Chemical Construction Corporation specializes in Refinery Acid Plants and offers highly efficient processes and equipment of its own design and under its own patent control. Contracts cover consultation, design and erection, and plant acceptance is asked only after guaranteed performance has been proven during a test run. The plant is delivered with operating crew trained for full capacity operation.

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MODEL TWO has been approved by Factory Mutual Laboratories. A new folder has been prepared which will be mailed on request.

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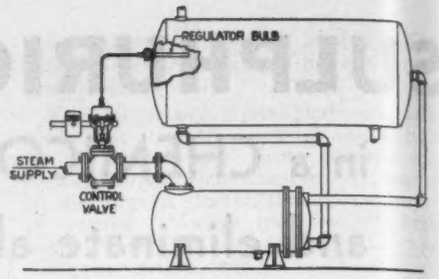
Effective Fire Protection for Refineries Bulk Plants Trucks

were covered with basket shields made by welding light rods and strap iron. The entire installation makes a neat and serviceable protective unit, preventing men from becoming entangled in the moving machinery.

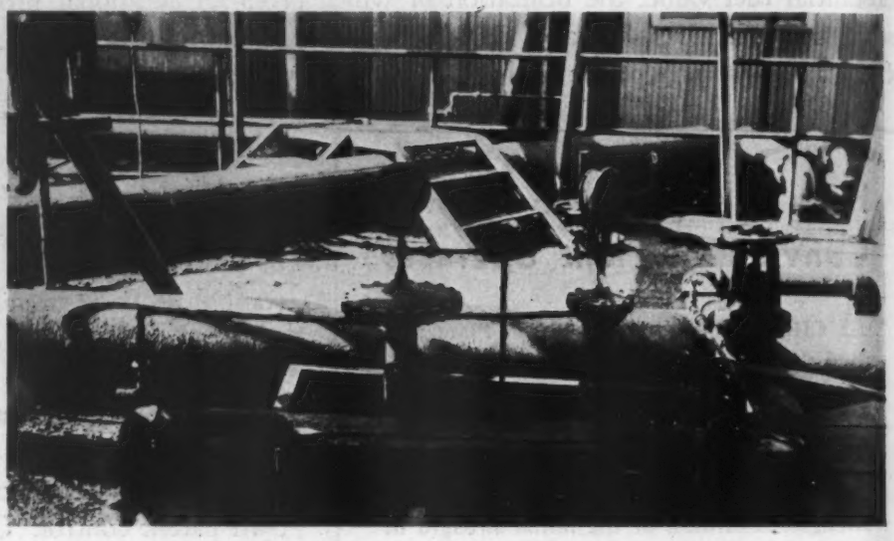
Automatic Water Make-up For Tower Basin

UNION Oil Company of California has installed an automatic water make up supply valve at its Bell compression station in Santa Fe Springs. Formerly, the water needed to replenish that dissipated through evaporation and wind losses was fed to the cooling tower basin through operation of a manually operated gate valve.



Hot Water System

A float placed in the make-up box beside the cooling tower basin is connected to a gas pressure line instead of to a float valve in the water supply system. As the water level falls, the action of the ball float releases gas to a diaphragm valve which causes the water control valve to open. The building up of the water in the basin reverses the process. When gas is cut off from the actuating valve it closes and cuts off the supply of water. Since this device was installed no difficulty has been encountered in the effective operation of the supply control.



Automatic Water Make-up for cooling tower basin

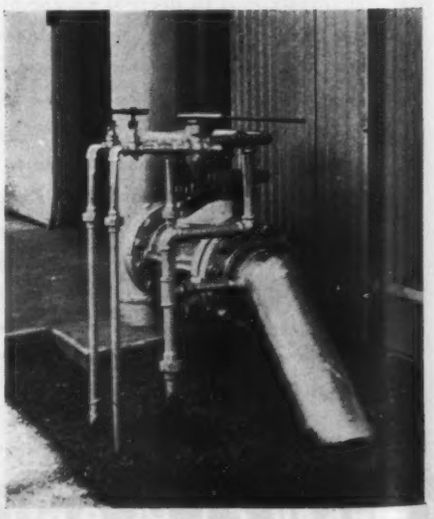
Simple Continuous Hot Water Supply

HEREWITH a diagram which shows an exceptionally simple "hook-up" for a self-regulating system of dependable hot water supply. The upper tank is a storage tank in which a "regulator bulb" is shown. This bulb maintains the desired temperature in the storage tank by operating the "control valve," which admits steam into the hot water heater below the storage tank.

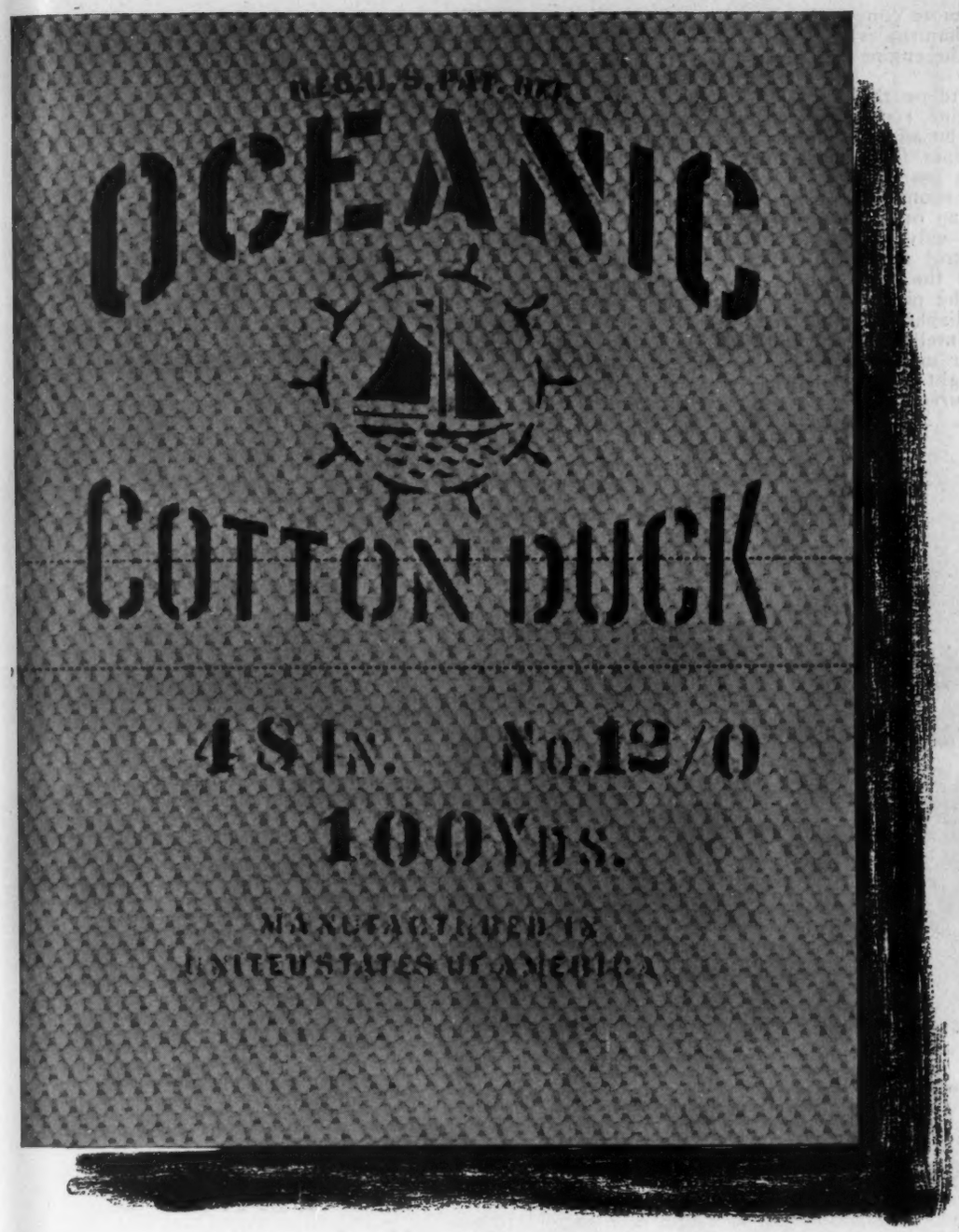
Thus when the temperature of the water in the storage tank becomes fractionally low the regulator bulb causes the control valve to open and admits steam into the heater. The hotter water in the heater then circulates upward into the storage tank, heating the water in that tank to the point where the bulb shuts off the steam supply through the control valve. It is a simple, comparatively inexpensive and positive method.

Emergency Gas Control Valve

MECHANICS and engineers working for Industrial Fuel Supply Company at its Ventura Avenue compressor station worked out a controller which is designed to shut down the engines in case of a break in the transmission line, or of fire in the plant. Its operation is not altogether automatic,



Emergency Gas Control Valves



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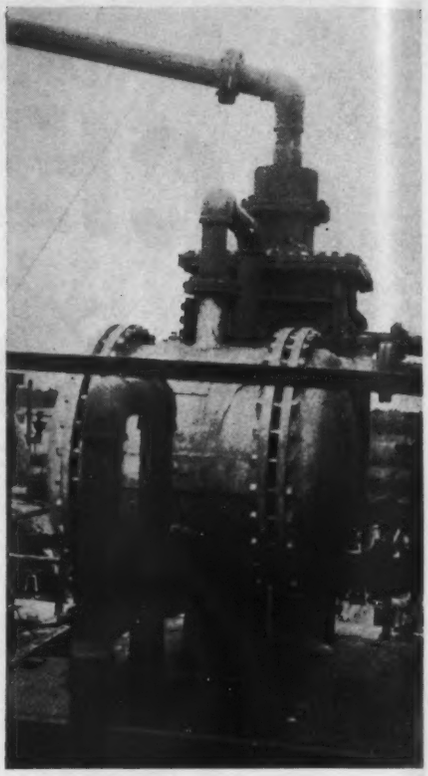
but what may be called a remote controller. The actuating mechanism is located at the main door in the engine room.

A diaphragm valve is placed on the fuel header beyond the engine room and at a point not likely to be affected by heat. A system of pipes from this valve is connected to a gas line near the door of the engine room. A valve in these lines permits an operator to cause the diaphragm valve to function by striking the control valve as he passes by. Gas from the line nearby is released through the piping arrangement and closes the diaphragm valve on the fuel line. Any intelligent mechanic may build a similar unit by giving the matter some thought as to details, action, and results desired.

Rearranged Condensers Prove More Efficient

OLD Dutch Refining Company was encountering difficulty in obtaining the desired temperature on condensed gasoline and other products, while the temperature of the stream stood around 100° F. during the warmer portions of the day. The condensers used in this plant are shell and tube units, and were piped so that the stream of vapors flowed in parallel.

While the superintendent was inspecting the unit, contemplating what he must do to obtain better temperatures, he also noticed that the back pressure was more than it should be under the circumstances. He had the connection foreman make some changes in the piping so that two condensers on the gasoline stream would operate in series. The piping was made so the primary unit would always remain full of condensate, and the final cooling occur on the second in line.



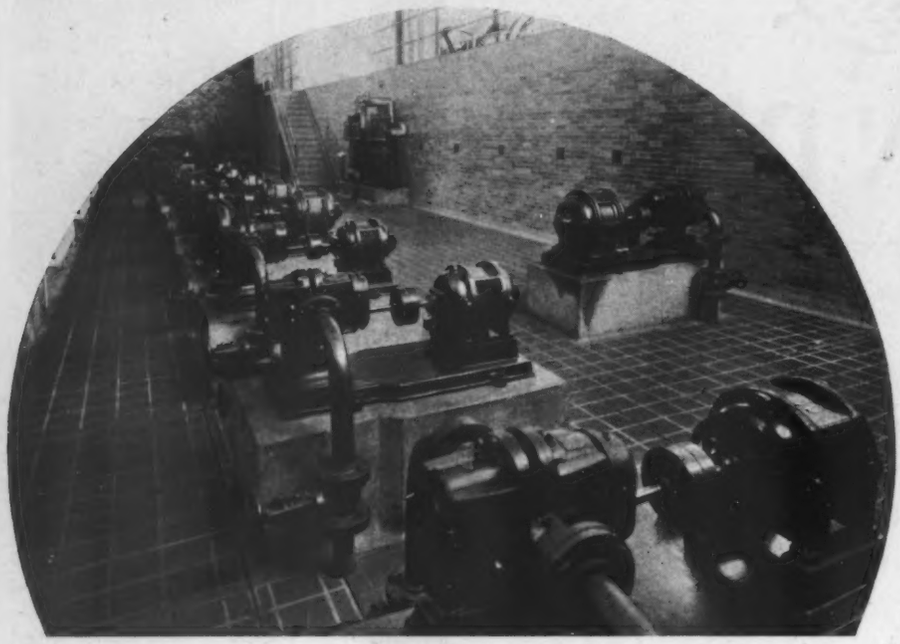
Two exchangers used as condensers on gasoline stream after being changed from parallel to series flow.

Immediately after the change was made, the temperature on the stream dropped to 80° F. with no other change in operation, or a larger volume of cooling water. After the success obtained with this unit, all others in the plant were changed likewise with good results.

1936 A. S. T. M. Meetings

THE 1936 (Thirty-ninth) A. S. T. M. annual meeting is to be held in Atlantic City from June 29 to July 3, inclusive, according to action taken by the executive committee. While the meeting normally would be held during the previous week, Atlantic City during that time is to be host to a large international organization and it was felt that the week which was chosen would result in better hotel accommodations.

It was decided also to hold the 1936 regional meeting in Pittsburgh, on Wednesday, March 4. Arrangements for this meeting will be sponsored by the Pittsburgh district committee. The program committee is developing a symposium on High Strength Construction Metals, and the committee of the society interested in this program are taking part in its development. During the week from March 2 to 6 the Spring group meetings of committees will be in progress.



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SCIENCE AND TECHNOLOGY

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REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by tile, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical Data Manufacture: Processes and Plant

Heat Transmission in the Evaporation of Liquids at Vertical and Horizontal Surfaces. M. JAKOV AND W. LINKE. *Physik. Z.* **36** (1935) pp. 267-80.

Carbon tetrachloride and water were evaporated from horizontal and vertical surfaces. The use of horizontal surfaces resulted in better heat transfer, presumably because of the earlier occurrence of turbulence. The heat transfer law does not hold beyond certain transmission limits, when bubbles of vapor form at the heating surface. Under this condition the heat transfer numbers were found to be directly proportional to the 0.8 power of the heating-surface output and inversely proportional to the square root of the surface tension. The equation of Cryder and Gilliland for heat transmission from polished metal surfaces to boiling liquids is not recommended. The author's own equation is

$$\frac{a}{\lambda} \cdot \sqrt{\frac{\sigma}{\gamma}} = 30 \cdot \left(\frac{H \cdot v}{r \cdot w}\right)^{0.8}$$

in which a is the heat-transfer no., the heat cond. of the liquid, γ the sp. gr., σ the surface tension, v the sp. vol. of saturated steam, r the heat of evaporation, w the number of bubbles formed at each place per unit time multiplied by the bubble diameter, and H the heating-surface output.

Factors Affecting Entrainment in Bubble-cap Columns. WILLIAM T. PYOTT, C. A. JACKSON AND R. L. HUNTINGTON. *Ind. Eng. Chem.* **27** (1935) pp. 821-25.

The authors report the result of studies of the effect of temperature, linear and mass velocities of vapors, plate spacing, and physical characteristics of the liquid on entrainment in a small bubble-cap column. Two systems were studied: kerosene-air, and water-air. Increase in temperatures produces the increase in entrainment. Entrainment is less the greater the tray spacing, the lower the linear velocity of the gas, and the less the rate of flow of liquid over the plates. It was found that entrainment plots as a straight line function of mass velocity on semi-logarithmic paper. Some data are also given on pressure drop across a plate as a function of liquid rate and linear velocity of vapor.

Applications of Distillation in Modern Petroleum Refining. J. S. CAREY. *Ind. Eng. Chem.* **27** (1935) pp. 795-801.

Conventional distillation equipment for the stabilization of crude, break-up of crude into light cuts and lubricating cuts, and rerunning of lubricating stock distillate is described. The article is illustrated with flow diagrams, and data on the various products secured are given in tabular form.

Liquid-Liquid Extraction Systems. T. G. HUNTER AND A. W. NASH. *Ind. Eng. Chem.* **27** (1935) pp. 836-45.

Extraction processes for liquid-liquid systems are coming to be of increased commercial importance. The newest and possibly the most important application is the solvent refining of lubricating oils. However, processes of certain types are now successfully used for the recovery of phenols from effluent liquors, for the winning of halogens from brines, for the dehydration of acetic acid, for the regeneration of alkali phenolates, for the refining of petroleum products, for the dewaxing of oil, and for asphalt removal. Extraction methods suitable for liquid-liquid systems are described and methods of computation applicable to these processes are briefly discussed. A graphical method employing triangular coordinates for representing equilibrium in complex oil-solvent systems is presented. Calculated and experimental results from both multiple and countercurrent extraction processes for refining different lubricating oil stock with nitrobenzene are compared. The methods presented are believed to be sufficiently accurate for most purposes.

Graphical Correlation of Solvent Extraction Data. STEWART S. KURTZ, JR. *Ind. Eng. Chem.* **27** (1935) pp. 845-6.

A method of plotting data obtained in the solvent extraction of petroleum hydrocarbon solutions that has been used for some time in the laboratory of the Atlantic Refining Company is presented. The method has the advantages that it is not necessary to define the components of the extracted mixtures, rectangular coordinate paper is used, and experimental data may be plotted directly. Detailed instructions for the use of the procedure are given, along with typical data, and a typical chart.

Solubility of Constituents of Mineral Oil and Tar in Liquid Hydrogen Sulphide. E. TERRES AND W. VOLLMER. *Petroleum,* **31** (1935) No. 19, 1-12.

Liquid hydrogen sulphide was studied as a selective solvent for refining mineral oil. Binary systems composed of hydrogen sulphide, with benzene, toluene, phenol, o-cresol, naphthalene, anthracene, phenanthrene, $C_{18}H_{38}$, cyclohexand, and quinoline were examined by constructing the freezing point curves for mixtures of various compositions. It was found that at 0°C. paraffin hydrocarbons, heterogeneous cyclic compounds, and monocyclic hydrocarbons are miscible in all proportions with liquid hydrogen sulphide. In fact, all of the organic substances examined form only one liquid phase with hydrogen sulphide. Double compounds, were, however, formed by toluene, phenol and quinoline; $C_{18}H_{38}$ and cyclohexane form mixed crystals.

The Effect of Pressure in the Process of Cracking. M. S. NEMTZOV. *Jour. Inst. Pet. Tech.* **21** (1935) pp. 644-53.

Data obtained recently, largely as the result of theoretical investigation of the reactions of individual hydrocarbons, lead to the conclusion that pressure has a substantial influence on the process and on the character of the products obtained in cracking. The author analyzes the problem in a methodical manner. He discusses the relation of pressure to (1) the formation of gases and the yields of gasoline, (2) the stability of cracked gasoline, and (3) anti-knock properties. Considering the assumptions derived from theoretical reasoning as being confirmed to a great extent by special investigation, particularly by those started at the Government High-pressure Institute at Petrograd, it may be stated that the basic processes for the preparation of high anti-knock gasoline obtained by severe cracking must be either reforming under pressure, or destructive hydrogenation, the latter being some kind of a severe reforming process effected in the presence of hydrogen.

Corrosion of the Petroleum Distillation Equipment and Its Prevention. S. M. SILAKOV. *Groznenskii Neftyanik* **4**, No. 8 (1934) pp. 35-41.

A number of known methods is discussed in detail. It is said that the admission of a jet of hot crude oil into pipe lines helps in breaking down the emulsions, thus lowering the ash content of the stock to be refined. The use of cracked residues is also satisfactory in breaking down the emulsions. The introduction of NH_3 and NaOH reduced corrosion, NaOH forming in addition a protective layer on the metal. A protection of the condensers was effected by the application of caustic in the mixing condensers. The use of Zn-naphthenate lowered the corrosive action of the oil and removed the gum forming ingredients. The Baku crude oil, part of which is now refined in Grozny, contains an ash with Na.., Ca.., MG.., Fe..., $SO4''$, Cl' ions and SiO_2. This ash content was considerably lowered by applying water of 60°C. twice, followed by a 6 hrs. settling period, the ash content thus being lowered from 0.088 to 0.058 and 0.039%. The formation of HCl in Baku crude oil was eliminated by treating it with 5% of a Grozny crude oil emulsion (the latter being broken up during the application) in addition to 0.1% of NaCl and 0.1% NaOH. Best effects, however, were noticed when using Zn-naphthenate. A literature index containing 10 references is appended.

Abs. from For. Pet. Tech., **3**, No. 2.

The First Refinery Scale Experiments in an Attempt to Lower the Corrosion Effect in the Refining of Baku Crude Oil. P. S. LISITZUIN, V. G. NIKOLAEVA AND K. V. ROZINKINA. *Groznenskii Neftyanik,* **4**, No. 8, (1934) pp. 49-51.

The amount of HCl present in crude oil (in emulsions) was lowered 15 times and the amount of iron carried off (dissolved from the equipment) was reduced 12 fold by the use of cracked residues and a preliminary NaOH treatment of the crude. The water separated in the above manner from a crude oil emulsion containing 58% crude oil carried off only 0.6% of the latter. The experiments are described.

Abs. from For. Pet. Tech., **3**, No. 2.

The Heat Capacity of Methane and Its Halogen Derivatives from Spectroscopic Data. R. D. VOLD. *Jour. Am. Chem. Soc.* **57** (1935) pp. 1192-5.

The molecular heat capacities of methane, methyl chloride, methylene chloride chloroform and carbon tetrachloride were calculated over the temperature range 0 to 500°C. from the

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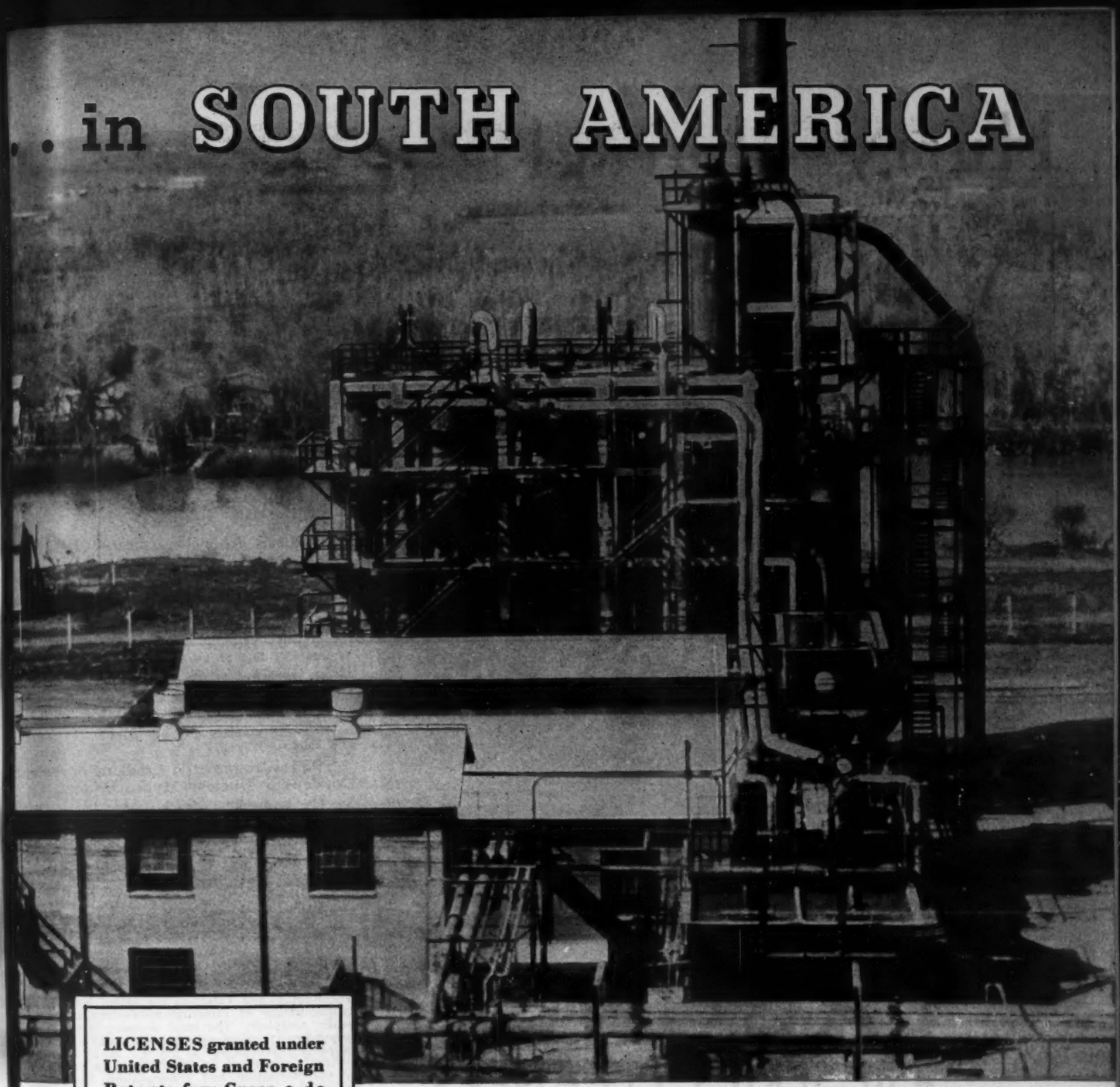

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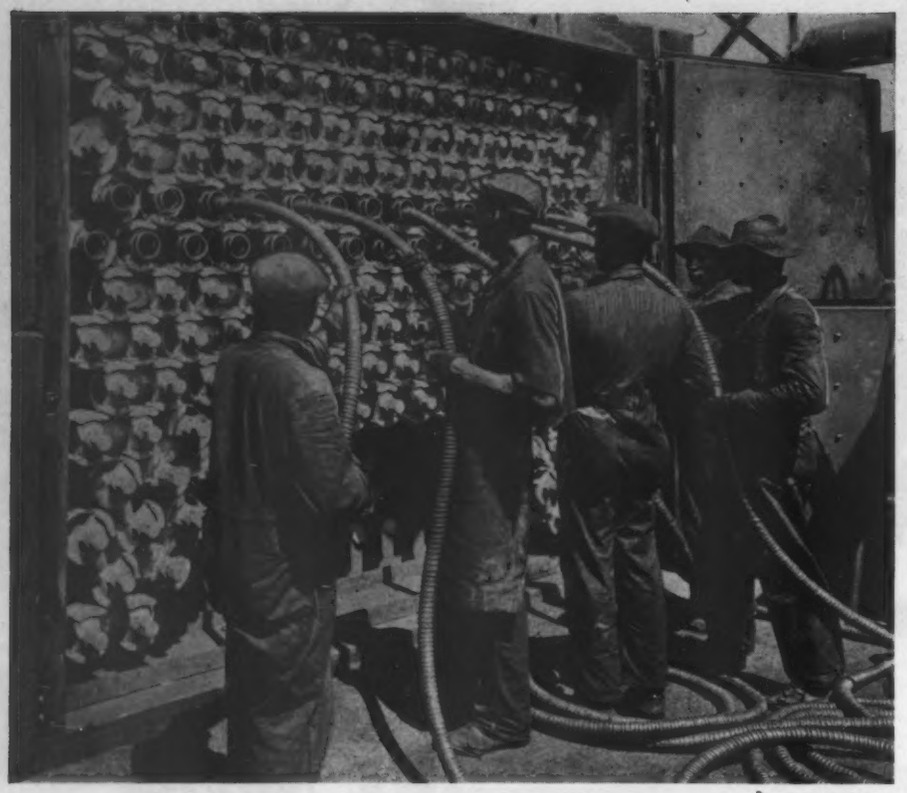

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Raman spectras of these substances. It is shown that the values so obtained are probably accurate to 3%, and are far more reliable than the fragmentary experimental thermal data.

Thermal Properties of Hydrocarbons under Pressure. II. JAMES D. LINDSAY AND GEORGE GRANGER BROWN. *Ind. Eng. Chem.* **27** (1935) pp. 817-20.

The effect of pressure on the isothermal change in enthalpy of normal pentane vapors is calculated, using the equation of state suggested by Young. It is found to agree with experimental data as previously recorded. The effect of pressure on the enthalpy of benzene vapors has been experimentally determined and used in the construction of an enthalpy-pressure-temperature chart. Values of benzene are found to be similar to those for pentane when compared on the basis of the isothermal decrease in enthalpy in B.t.u. per °R per pound mole at the same reduced temperature and over the same increment in reduced pressure. The data are presented in some detail in tabular and graphical form.

Chemical Composition and Reactions

Synthesis from Unsaturated Hydrocarbons. J. A. NIEUWLAND. *Ind. Eng. Chem.* **27** (1935) pp. 850-4.

The paper is the medalist's address upon the occasion of the award of the Nichols medal by the New York section of the American Chemical Society. The reactions of acetylene, and particularly the catalytic reactions, are described. It was this line of work by Father Nieuwland that ultimately resulted in the synthesis of the only successful commercial synthetic rubber Duprene. The work is of interest to petroleum refiners because of its possible extension through the utilization of other unsaturated hydrocarbons in the making of many possible by-products materials.

The Hydrogenation-Cracking of some Condensed Nuclear Hydrocarbons. C. C. HALL. *Chem. & Ind.* **54** (1935) pp. 208T-17T.

The hydrogenation-cracking of 1- and 2-methylnaphthalene and of 2:6-dimethylnaphthalene proceeds in a manner similar to that of naphthalene. Little reaction occurs at 450°C. in the absence of catalyst. The author used a two-litre rotating converter at a pressure of 220-250 atm. and with an initial hydrogen pressure of 100 atm. The time period of two hours was in general used. In the presence of supported molybdenum oxide catalysts at 400° the monomethylnaphthalenes are hydrogenated to the extent of 80 to 90%, and dimethylnaphthalenes to the extent of 60%. In the presence of molybdenum sulfide catalysts for seven hours the hydrogenation of dimethylnaphthalene is practically complete. The main product is the corresponding tetrahydromethylnaphthalene. In the temperature range 300 to 500°C. 30 to 50% of indene is converted into more complex products by polymerisation and condensation, independent of the presence of a molybdenum catalyst. At lower temperatures truxene and liquid polymerides predominate and at higher temperatures the resins and their decomposition products are formed. The remaining material behaves similarly to the hydrocarbons of the naphthalene series. Hydrindene is formed by hydrogenation of the ethylenic linking, and above 400°C. is decomposed independently of the presence a molybdenum catalyst, forming benzene hydrocarbons, largely toluene.

Ethylbenzene decomposes under hydrogenation-cracking conditions in the absence of a catalyst, with benzene and ethane as the sole products. At 480° o-xylene yields 47% of toluene and 2% of benzene; ethylbenzene yields 32% of benzene, and toluene gives 13% of benzene.

The Properties of Unsaturated Sulfur Compounds. I. Alpha Beta Unsaturated Sulfones. E. P. KOHLER AND H. POTTER. *Jour. Am. Chem. Soc.* **57** (1935) pp. 1316-21.

The reactions of the sulfones and sulfoxides are of interest in connection with chemical treating procedures for the removal of sulfur compounds. The authors have studied a large number of sulfones and find that the unsaturated sulfones add metallic derivatives including Grignard reagents precisely like a, B-unsaturated ketones. Saturated sulfones behave toward Grignard reagents like saturated ketones.

The Corrosion Problem in Refineries. N. I. NYURENBERG. *Groznenskii Neftyanik*, **4** No. 8, (1934) pp. 33-4.

The crude oil to be refined contains an aver-

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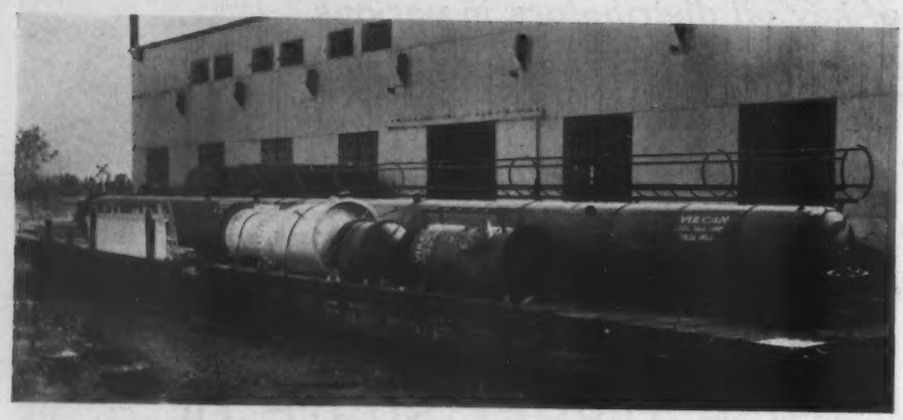

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age of 0.3 and a maximum of 0.8% ash, this causing crust formation in the stills. By improving the settling apparatus, washing the crude with water and preheating it to a higher temperature the ash content was lowered to a considerable extent. The presence of $MgCl_2$ and S compounds in the oil causes corrosion of the apparatus. The corrosion caused by $MgCl_2$ may be lowered by thorough washing and neutralization (using about 0.02% of NaOH). Best results were obtained, however, by introducing a mixture of NaOH and 5% of a cracked residue, the latter destroying the emulsion formed through NaOH, the working temperature being 90°C. S is removed by treatment in the liquid or vapor phase with Zn-naphthenates, this treatment lowering the S content from 0.003 to 0.001%. The corrosion of the storage tanks caused by S can be minimized by placing on the bottom of the tanks a deposit of a metal which has an anodic effect, the iron of the tank being the cathode. The parts of apparatus used for distillation and exposed to the action of S at high temperatures should be plated with Cr-Ni steel.

Abs. from For. Pet. Tech., 3, No. 2.

Eliminating the Corrosive Properties of Cracked Gasoline. L. SEL'SKII. *Groznenskii Neftyanik*, **4**, No. 8, (1934) pp. 45-9.

The corrosion of distilling apparatus was eliminated by introducing a NaOH solution into the pipe line used for the pressure distillate, the caustic being recycled until the gasoline showed again corrosive properties. It was found that a gasoline which received a preliminary caustic treatment did not corrode the apparatus after a H_2SO_4 treatment followed by redistillation, while a gasoline treated with H_2SO_4, followed by washing and alkali treatment was corrosive even though the original gasoline was not. A gasoline treated with NaOH loses some of the S compounds, which is also the case on redistillation. The use of a solution of $CA(OH)_2$ on refinery scale is accompanied by the formation of emulsions, while satisfactory results could not be attained with NH_3. A detailed description of the experiments is given.

Abs. from For. Pet. Tech. 3, No. 2.

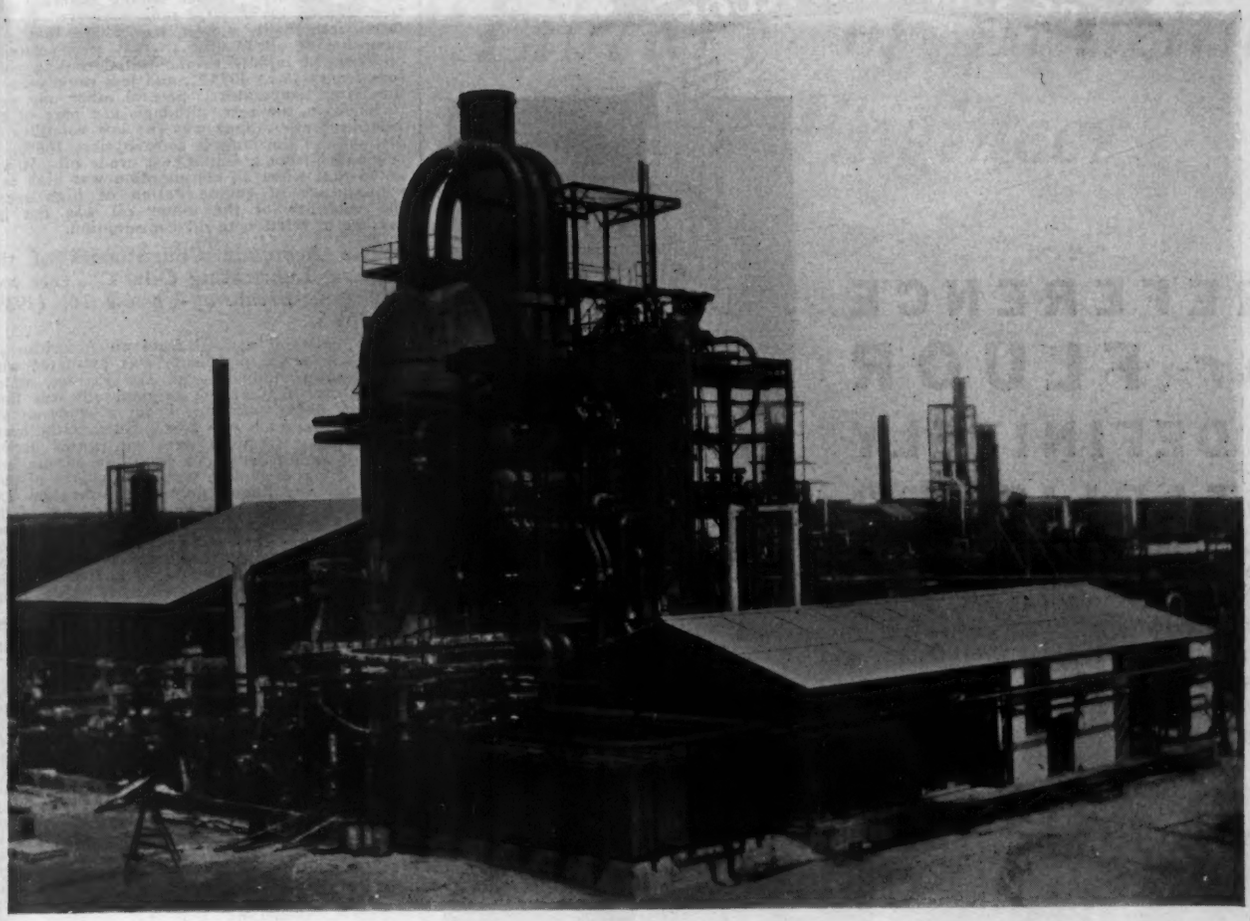
Recent Developments in Manufacturing and Using Refractories. LOUIS J. TROSTEL. *Chem. & Met. Eng.* **42** (1935) pp. 363-7.

Recent trends and improvements in the manufacture of refractories are outlined. New refractories available as the result of scientific processing are described. A so-called super-duty fireclay brick is now available that represents the most advanced development of strictly fireclay brick. It is characterized by high density and volume stability. Spalling rarely exceeds 1% loss in the A.S.T.M. panel spalling test. The linear shrinkage after heating for five hours at 1600°C. does not exceed .5%. At a temperature of 1600°C. fireclay refractories are at a disadvantage that they will never be able entirely to overcome. At this temperature, as shown by the phase equilibrium diagram of the binary system SiO_2-Al_2O_3 they are 45% liquid and 55% crystalline mullite. The logical trend, therefore, has been to a mineral that can readily be converted to nearly 100% crystalline mullite. The highly crystallized members of the sillimanite group are the closest approach to this ideal. Accordingly, refractories have been made from members of this group such as cyanite, sillimanite, andalusite, and dumorierite. The production of refractories without burning that would be as good as fired ones has always attracted the refractories producer. Recently trouble from a lack of bond and volume stability have been overcome in the refractories recently developed by the General Refractories Company. The product is known as Ritex. Insulating firebricks are described. Efforts have been directed towards making a brick with high thermal resistance, but without too much sacrifice of strength. Various applications of the newer refractories are described.

Products:
Properties and Utilization

Oil Volatility Directly Related to Oil Consumption. L. L. DAVIS AND R. D. BEST. Paper presented before the A. S. T. M. Meeting at Detroit, June 24-28, 1935.

The trend towards the increased use of light automobile lubricating oils has raised a number of problems both as to manufacture and as to the utility of these oils. At 150 vis. at 100°F. neutral can be blended with bright stock to make S. A. E. 30 oil. Over three times as much motor oil can be made from a given volume of cracked distillate than if 300 vis. neutral is required. A series of oils was prepared that



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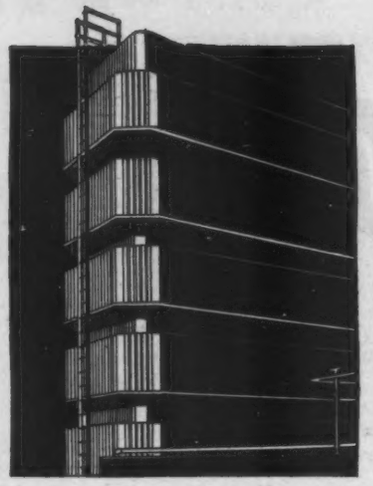

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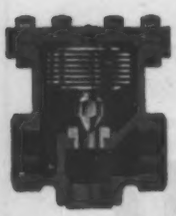

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differed amongst the members in volatility, but not in viscosity. Initial boiling points varied from 336 to 496°F. at 2 mm. pressure. Engine tests were made, and it was found that consumption of oil relative to that of a reference oil dropped rapidly as the initial boiling point rose from 336 to 408°F., and less rapidly above the latter temperature. Several other oils were included in the test, although not part of the volatility series. One was the low volatility index showed the highest consumption, 168%. It originated from a Gulf Coast crude oil. It was noted that when oil consumption was high as a consequence of engine design or high speed, the volatility of the motor oil was not important in relation to oil consumption.

The Aromatic Constituents of the Mineral Lubricating Oils. I. ZERBE AND FOLKENS. *Brennstoff-Chemie* **16,** (1935) pp. 161-5.

A spindle oil derived from an American asphalt-base crude petroleum was extracted with liquid sulfur dioxide, and the extract, which was 20 to 30% of the original oil, was fractionated under vacuum. From a study of absorption spectra it was concluded that the lower boiling point fractions were substituted derivatives of naphthalene and possibly benzene, and those of higher boiling point derivatives of phenanthrene and lighter polycyclic aromatics. The conclusions with reference to the nature of the fractions were confirmed by thermally decomposing them. This resulted in the production of the parent hydrocarbon. The original oil and the raffinate and extract were studied from the standpoint of temperature-viscosity relationship.

The Boundary Friction of Oxidised Lubricating Oils. E. R. REDGROVE. *Jour. Inst. Pet. Tech.* **21** (1935) pp. 612-43.

Both the oxidation and oiliness of lubricating oils have been extensively studied, but only recently has the importance of studying these two properties in conjunction with one another been realized. Work on this subject is reviewed by the author. All lubricating oils contain organic acid in small amounts, the content invariably increasing under the mildest oxidising conditions of service. Under more severe conditions a variety of oxygenated compounds is formed, including reactive volatile acids, relatively inert less volatile acids, asphaltic, pitchy, and even carbon-like material. These products result from diverse chemical changes, including oxidation, reduction, cracking, polymerization and distillation. The author desired to determine whether these oxygenated products are, like the higher molecular-weight fatty acids, beneficial to lubrication. It was found that the static friction of paraffin oil containing small percentages of various fatty acids decreases with increase of temperature and is proportional to the length of the hydrocarbon chain normal to the bearing surfaces attached to the adsorbed polar group. Non-volatile acids formed by oxidation of mineral lubricating oils eliminate the friction-temperature rise that normally occurs with unoxidised mineral oil. Some of these acids are assumed to be multi-polar, and to form an adsorbed film that is resistant to mechanical rupture. Decomposition products result in an increase in static-friction.

Are Metals Permeable by Oil? Experiment shows that Leaded Bronze and Babbitt Metal Absorb Oil. A. H. GILL. *Mech. Eng.* **57** (1935) p. 413.

It was found by Woodbury in 1880 that when two disks rubbed together in the Ordway-Woodbury machine, one being of hard bronze and the other of hardened steel, the characteristics of the oil previously used persisted even after 35 to 40 miles of attrition. Conradson found in testing pieces from a locomotive driving-journal brass that had been in long and satisfactory service, that oil came out of the metal in quantities as the pressure increased. Using a Babbitt metal bearing in a Galena testing machine he found that part of the oil disappeared after a test had been run for several days. Removal of the bearing showed that the cavities were full of oil. In another case oil was squeezed out of the bearings of hard bronze that was used in an oil-testing machine. Also, bronze chips obtained from the bronze metal tested by Conradson showed an oil content of 0.377 weight percent, and this oil content was practically uniform throughout the portion of the cylinder cut off. Chips from the steel cylinder in a locomotive driving journal showed no oil upon extraction, nor did chips taken from a cast iron journal. Absorption appears to be limited to bronze, and, according to Conradson, to babbitt metal.

A Procedure for Classification of Hydrocarbons. SAMUEL P. MULLIKEN AND REGINALD I. WAKEMAN. *Ind. Eng. Chem., Anal. Ed.,* **7,** (1935) pp. 275-7.

A procedure is described for use in qualitative organic analysis, and permits the classifica-

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tion of hydrocarbons according to their structure. The liquid hydrocarbons covered are the aromatic, unsaturated non-aromatic, alkenes, cycloalkanes and alkanes, and amongst the solid hydrocarbons the aromatics and non-aromatics. The method is based upon the miscibility of the hydrocarbons with nitromethane, aniline, and benzyl alcohol, the bromide-bromate titration of unsaturation, and upon the usual physical constants such melting point, boiling point, and density.

Improved Methods of Examining Mineral Oils, Especially the High Boiling Components. J. C. VLUGTER, H. I. WATERMAN AND H. A. VAN WESTEN. *Jour. Inst. Pet. Tech.* **21** (1935) pp. 661-76.

A new method is given for the analysis of hydrocarbon oils such as lubricating oils. No physical or chemical separation of the groups of hydrocarbons is made, but the results of the analysis are expressed as percentages of aromatic rings, naphthenic rings, paraffins as such, or as paraffinic side-chains. The data required are, molecular weight, refractive index, density and aniline point. Aromatic rings can be determined from the change in physical constants occurring upon complete hydrogenation. The proportion of naphthenic and paraffinic rings in the fully hydrogenated oil can then be determined from properties of this oil. Because a great many oils have been examined, actual hydrogenation is no longer required, since the constants of the completely hydrogenated oil can be predicted from those of the original oil. Density is determined by means of a Sprengel pycnometer, and the index of refraction by means of the Abbe refractometer. These constants must be known accurately to the fourth decimal place in order to permit calculation of the specific refractions to four decimal places. The percentage of carbon and hydrogen in the oil is determined from the specific refractions rather than from ultimate analysis, because the former is more accurate. Details and procedure are described, charts are given for use in connection with the preparation of data secured by these figures, and use of the data in the calculations is illustrated.

A Photoelectric Colorimeter. JOHN H. YOE AND THOMAS B. CRUMPLER. *Ind. Eng. Chem., Anal. Ed.*, **7** (1935) pp. 281-4.

The photoelectric colorimeter described is a self-contained instrument of moderate cost that has resulted from several years of investigation in the laboratory. Many arrangements of the optical and electrical systems were tried with varying success. The instrument described in this article is stated by the author to have proved satisfactory. The advantages are greater sensitivity and elimination of errors resulting from eye fatigue and to the inability of the observer to judge color intensities accurately. The use of the instrument is described and typical results are presented.

Absolute Color Determination of Mineral Oil by Absorption Measurements. E. L. LEDERER. *Petroleum*, **31** (1935) No. 21, 1-4.

On the basis of theoretical considerations regarding light absorption in the visible spectrum, formulae are derived whereby the color of an oil is defined by two constants, visibly, F_t (color depth) and F_s (color cast). These can be obtained graphically. F_t is defined as the log of the extinction coefficient at the point of maximum intensity in the sun's spectrum (530 mu), and F_s as the tangent of the angle of the straight line produced by plotting the extinction coefficient on the special graphical system. As F_s increases, the color changes from yellow to red, while the greater is F_t the darker the color. For yellow oils, F_t may be negative. The procedure can be used to follow color changes in artificially aged oils, as, far example, by the Sligh test. If oils have different chemical composition, the constants differ.

A Pressure Regulator for Vacuum Distillation. O. J. SCHIERHOLTZ. *Ind. Eng. Chem., Anal. Ed.*, **7** (1935) p. 284.

A simple, rugged and fool-proof apparatus for use as a pressure regulator in vacuum distillation is described. The device is not intended to function with the most extreme accuracy, but will control pressure within the accuracy of laboratory thermometers over a wide range. The regulator operates on the flutter-valve principle, which makes for smooth operation. The control is secured within 1 mm. over the entire range.

New Equipment for the Modern Plant

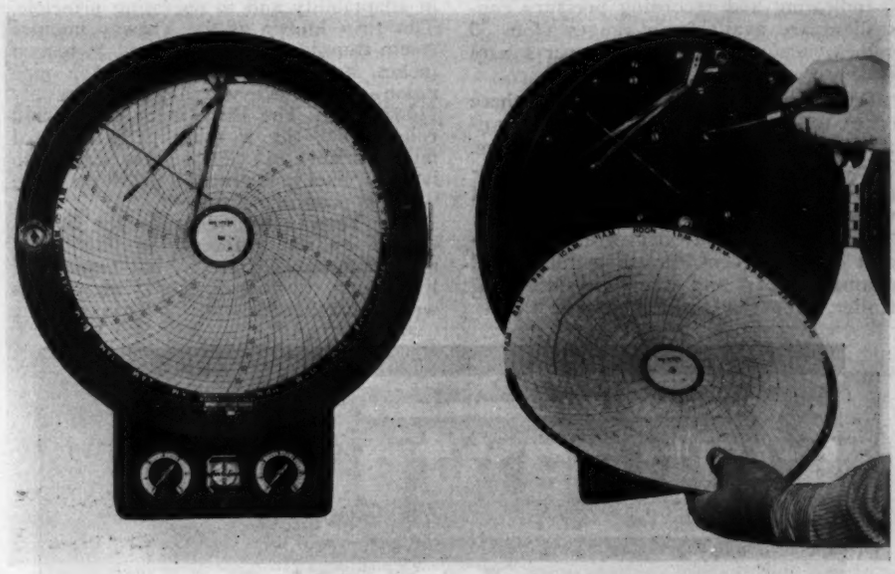
Magnetos
WICO ELECTRIC COMPANY

Wico Electric Company, Springfield, Massachusetts, has announced the new Series AP magnetoes with balanced electrical circuit, precision breaker construction, high speed needle bearings, and circulating lubrication. The new model weighs only 7¾ pounds with impulse coupling dust cover and adaptor plate. Fixed or variable spark is available, while the range of application includes one, two, three, four and six cylinder engines; in two- and four-cycle models. A timing mark and pointer provides for easy timing of the magneto to the engine upon the removal of the distributor cap.

Air Operated Controllers
THE BROWN INSTRUMENT CO.

The Brown Instrument Company, Wayne and Roberts Ave., Philadelphia, announces a new line of recording and indicating air operated controllers for temperature, flow, pressure and liquid level.

The "Air-o-Line" is a controller with one percent to 150 percent throttling range and automatic reset. This control system recognizes and corrects for the magnitude, rate and direction of departure from the control point. These instruments are capable of full automatic control and will maintain a process at the control point within extremely close limits.



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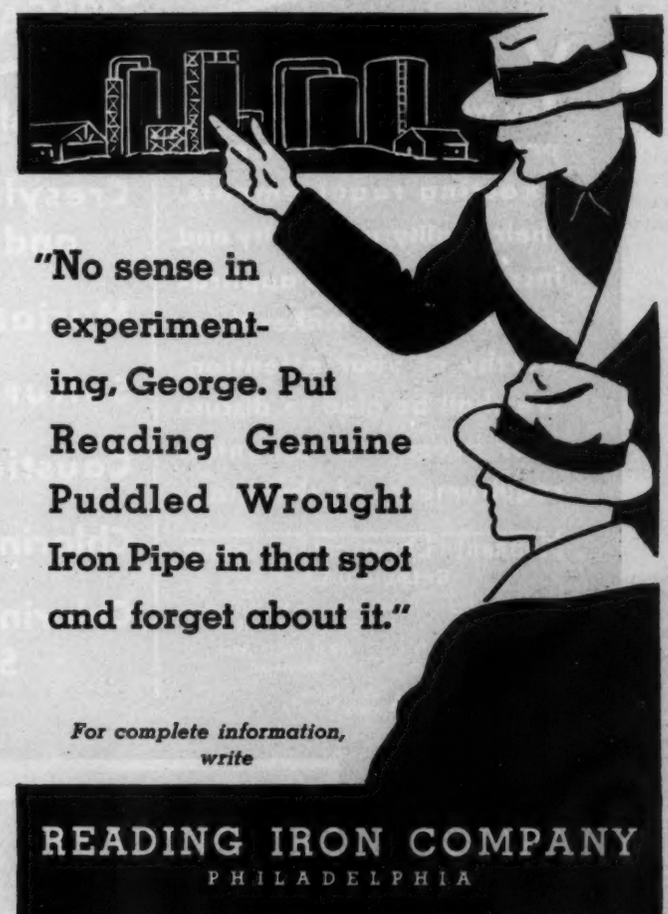
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ductance bridge type and the mechanical type. Thus, the remote operating characteristics of the electric flow meter and the flexibility of air operated control are combined in one controller.

Indicating and recording pressure controllers are available in ranges from 30 inches vacuum to 3000 pounds per square inch pressure.

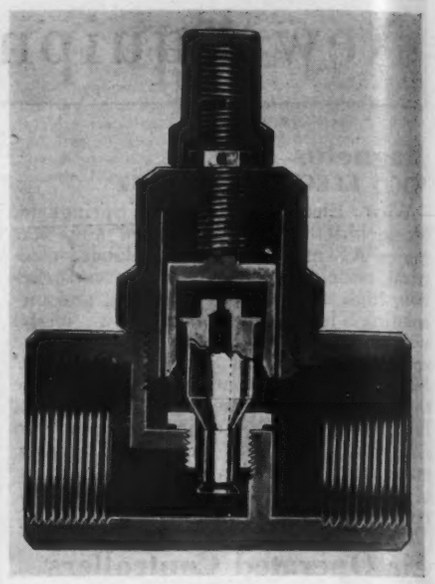
In addition to the "Air-o-Line," three other types of Brown air operated controllers are included in the new line. These are, the "Full Throttle," a controller with one percent to 150 percent throttling range and manual reset; the "Throttler," a controller with one percent to 10 percent throttling range and manual reset; and the "On-Off Controller," for two-position service.

Steam Trap

YARNALL-WARING COMPANY

Yarnall-Waring Company, Philadelphia, announces steam trap, new in appearance, in adaptability and in operating principle. This trap, known as the Yarway impulse steam trap, is made in six sizes, ½ to two inches, and is little larger than a pipe union—the ½-inch size shown, weighs only 1⅛ pounds. The body is made of cold rolled steel, the working parts of hard monel, bonnet and cap of brass. Each trap is factory-set to operate all pressures from 0 to 400 pounds.

The Yarway trap depends for its operation on the difference in flow characteristics of cold water, hot water and live steam, flowing through two orifices with a chamber between. There is only one moving part, the valve disc itself, shown in section view above. Movement of this valve-disc is governed by variations in pressure in the space above valve piston called the control chamber. These changes in pressure occurring with changes in temperature of condensate ranging from cold water to water at steam temperature.



Yarnell-Warring Steam Trap

When handling cold water, the pressure under valve piston (inlet side of trap) is greater than the reduced pressure in control chamber above piston—clearance between piston and cylinder acting as first orifice—and valve opens to allow free discharge of condensate. As the accumulation of cold condensate disappears the remaining condensate approaches steam temperature, flashing takes place in control orifice in center of valve disc, the flow is choked and the pressure in control chamber builds up to close valve. Valve disc, piston and center orifice area accurately proportioned to give positive opening of valve when cold condensate collects and quick closing when pipe system is hot and there is no condensate or the condensate is at or near steam temperature.

The manufacturer states that the merits of this design have been conclusively proved by exhaustive tests in the Yarway steam laboratory and by two years of actual service under a wide variety of conditions in leading industrial plants.

Globe Valve

CONSOLIDATED ASHCROFT HANCOCK COMPANY

Consolidated Ashcroft Hancock Company, Hancock Valve Division, Bridgeport, Conn., announces a new union bonnet bronze globe valve. This valve has a number of features which it is claimed greatly increase its wearing qualities. These include superhard stainless steel valve discs and seat rings (hardened to 500 Brinell), which are said to prevent wire drawing, steam cutting and galling.

The disc is attached to the stem in a new way that insures correct seating and facilitates regrinding.

Special types of bronze have been developed for the valve stem and bonnet which the makers claim greatly lengthen the service life of this valve.

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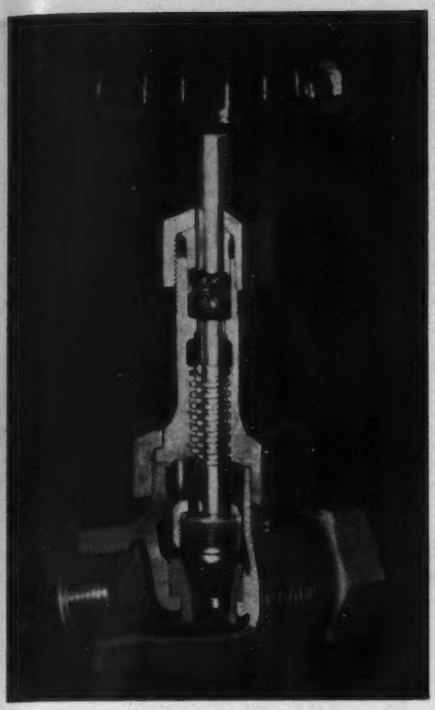


Hancock Valve

seating and permits easy repacking while the valve is in pressure service. Made for steam pressures up to 300 pounds, these new bronze valve are available in both globe and angle patterns.

Oil Thief

W. L. WALKER COMPANY

W. L. Walker Company, Tulsa, Oklahoma, has announced a new type oil thief that recently was perfected by E. W. Pribble. The company claims that the new oil thief is easy to operate, and that it will penetrate all basic sediment. The improved model reaches fully to the tank bottom before tripping, and does not stir or mix the oil with the basic sediment, the manufacturer claims. Operation is simple, and the material used does not create an electrical spark. The thief is leak-proof and furnishes tests for basic sediment content at pipe line opening. The body is of cast aluminum and all fittings are made of brass. When in position, the master gage oil thief will not roll or topple over, it is claimed.

Pipe Cutting Machine

OSTER-WILLIAMS

Oster-Williams, Cleveland, Ohio, has announced a new type pipe cutting machine which the manufacturer claims will perform a task formerly done only by skilled hand labor. The machine was designed primarily for cutting pipe intersections, and duplicates in design any pattern required. The finished surface has the appearance of a lathe tool cut. The cutting torch is guided by an ingenious mechanism that is almost uncanny in its ability to duplicate the motion of the torch held in an operator's hand. It will cut any size pipe from 2½ to 12 inches in diameter, making full size tees or reducing tees to 90 degrees, branch reducing tees from 45 to 90 degrees, elbow miters, Y's and blunt bull plugs.

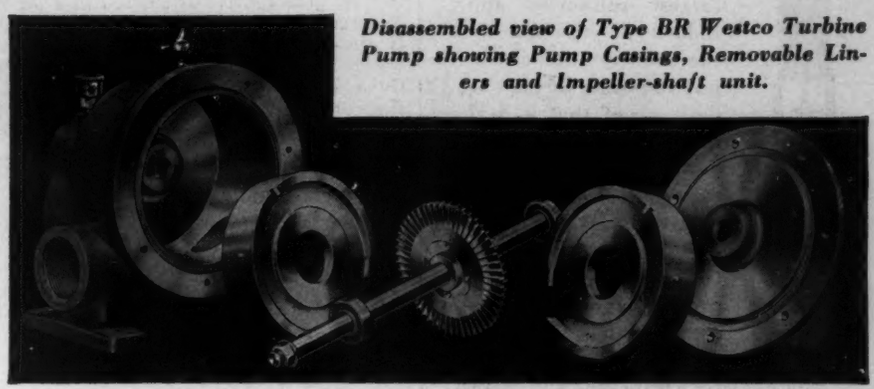
The machine is similar in appearance to a radial drill press. The generating case is made of aluminum and is mounted on a rotating column which can be swung in any direction and readily positioned to the end or side of the pipe for the various cuts. The pipe is placed on ball bearing rollers, housed in adjustable supports resting on double rails mounted on the welded steel base of the machine. If the end of the pipe is to be cut off for butt or tee welding, the pipe section is placed through the aluminum torch carrier ring. If a hole is to be cut in the side of the pipe, the torch carrier ring is swung around until it faces the side of the pipe. No templates are needed for the cut, and for the difficult cuts it is necessary to make only five simple settings.

Orifice

BAILEY METER COMPANY

Bailey Meter Company, Cleveland, Ohio, announces an adjustable orifice which automatically shifts its position in accordance with major changes in rate of flow. This device, when installed in a pipe line and connected to a standard recording and integrating fluid meter, greatly widens the flow range which may be accurately covered by the meter.

The Bailey automatic adjustable orifice is similar in appearance to a hydraulically operated gate valve. The gate, however, is a sharp edged orifice segment, coefficients for which have been accurately determined. Its position varies the size



Disassembled view of Type BR Westco Turbine Pump showing Pump Casings, Removable Liners and Impeller-shaft unit.

Longer Life from Pump Casings

New Westco Feature saves money for pump users

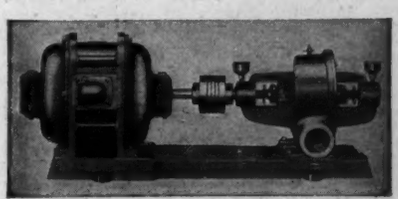
PATENTED Removable Liners now provide a complete lining for Westco Pump casings. These Liners form the liquid channel and are quickly and easily removed from the casings. Besides protecting the casings against possible wear and corrosion, Removable Liners have 3 other valuable advantages. They are:

1. *Less metal required for alloy construction.*
2. *"Stand-by" pump protection at about ¼ usual cost.*
3. *Capacity of pump can be increased or decreased.*

Superior Construction

All Westcos have a double-suction intake which creates a perfect hydraulic balance within the pump. Casings are vertically split for quick, easy removal of Liners, Impeller-shaft unit and bearings (complete disassembly) without disturbing suction or discharge connections.

These pumps are favorites throughout the industry for Still Charging and for handling Hot Oil, Fuller's Earth, Chlorine Treating Solutions, Mineral Seal Oils, Naphtha, Chemicals, Brine, Water, etc.



Type BR Westco Turbine Pump

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of the orifice opening through which the fluid measured must pass.

Movable stops limit the stroke of the hydraulic piston so that the orifice segment rests in either one of two definite positions. The piston which positions the orifice is actuated by a solenoid operated valve, which in turn is commanded by contacts made in the recording meter. Through the solenoid valve, hydraulic pressure is admitted to either end of the cylinder and the other end is opened to drain.

When the differential pressure across the adjustable orifice reaches a predetermined minimum or maximum, a contactor within the meter casing energizes the solenoid valve, automatically changing the orifice opening to correspond with a new capacity. Simultaneously with this change, the integrator drive is shifted to a second Warren motor so it continues to accurately measure the total flow regardless of the orifice position. In addition to changing the orifice position and integrator speed, the contactor also energizes a small solenoid which operates an auxiliary recording pen to show the proper multiplying factor to be applied to the corresponding flow record on the chart.

Under an increasing flow condition, the orifice shifts position at a higher rate of flow than it does under a decreasing flow condition. This overlap prevents constant shifting when conditions are such that the flow holds closely to the changeover point.

Portable Air Compressors

WORTHINGTON PUMP & MACHINERY CORPORATION

Worthington Pump & Machinery Corporation, Harrison, New Jersey, announces four models of Aero-Two-Stage portable compressors for delivering 105, 160, 210, and 315 cubic feet of actual air per minute (A.S.M.E. standard test), for use wherever a mobile compressed air plant is needed.

Advanced design features, it is said, insure highest efficiency and endurance with delivery of the greatest volume of air at lowest fuel and maintenance cost. For example the 105, 160, and 210 models are compact, convenient and complete compressed air plant units. They are balanced-angle, two-stage, air-cooled, unit-assembly, with clutch connection to heavy-duty six-cylinder gasoline engines. Speed, 830 r.p.m. Air pressure, 100 pounds gauge. Bores, strokes, and number of cylinders differ in the various models. The compressors are equipped with improved feather valves, ring-type cooling fins, articulated connecting rods, drop-forged crankshaft, Timken roller bearings, spray and force-feed lubrication, oil filter, and V-belt-driven cooling fan. The engines are Hercules, heavy duty, with seven-bearing crankshaft, removable cylinder sleeves, exhaust valve inserts, permanent oil filter, fuel strainer, roller bearing V-belt-driven fan, and other modern features. Mounting of the unit depends upon requirements and size. Thus the 105 model may be had as follows: skid-mounted; steel wheel; solid rubber or pneumatic tired towabout; four-wheel solid rubber or pneumatic tired spring trailer; two-wheel single-axle spring trailer with solid rubber or pneumatic tires; truck-mounted; power take-off drive; rail car; mine car.

Simplified Scale Control

Just pour a small quantity of Sand-Banum in the boiler or engine (regardless of the water's chemical content) and rest assured that it is IMPOSSIBLE FOR SCALE TO FORM!

No storing of big, bulky drums; no daily treatment or handling of large quantities of chemicals; no shut-downs, no turbining, no costly repairs and LOST TIME when Sand-Banum is on the job!

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